Nova Scotia's SNOWSHOE HARE
Life History and Management

Donald G. Dodds

Nova Scotia
Department of
Lands and Forests

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Foreword

In 1971, to answer the common questions about one of our most popular wildlife species, the Department of Lands and Forests published the bulletin *Snowshow Hare in Nova Scotia* by Neil van Nostrand. Keeping up with demand required three additional printings and prompted us to consider a more comprehensive report. *Nova Scotia's Snowshoe Hare: Life History and Management*, is intended to fill that need.

Donald G. Dodds has had a life-long interest in snowshoe hare. He earned his PhD studying hare in Newfoundland, and during his career in Nova Scotia as wildlife manager and educator, Dr. Dodds has had research papers published in the *Journal of Wildlife Management*, the *Journal of Mammology* and the *Wildlife Society Bulletin*, and in other professional journals.

The hare continues to be of great interest to Nova Scotians. We hope this publication will answer most of your questions.

Anthony P. Duke

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The Snowshoe Hare and Its Relatives

The complete scientific name of the Nova Scotia snowshoe hare is *Lepus americanus struthopus* (Bangs). Living things are given scientific names to properly classify them in a systematic order that indicates relationships and allows us to know exactly which animal or plant we are talking about. There are often many common names but only one scientific name. Common names for the snowshoe hare are "varying hare", "snowshoe rabbit" and "snowshoe hare". Other lighter and quaintly descriptive names are "galloping ghost", "birch rabbit" and "satchel foot". In French, our hare is "Lièvre d'Amerique".

The scientific name is a "trinomial", meaning, three names. It is composed of the generic name, *Lepus*, coined by Linnaeus in 1758; the specific name, *americanus*, from Erxleben in 1777; and the subspecific name, *struthopus*, published by Outram Bangs of Harvard University in 1898. The genus *Lepus* is one of 10 genera in the family *Leporidae*, the hares and rabbits, while *Leporidae* refers to one of two families of the order *Lagomorpha* which also includes the pikas or conies. To show where the snowshoe hare fits into the general classification scheme of animals, an annotated ranking is presented in Figure 1.

The closest relatives of our Nova Scotia hare are the various subspecies of the species *americanus*. A general definition of a species is "a group of individuals of common ancestry which closely

FIGURE 1 CLASSIFICATION OF THE NOVA SCOTIA SNOWSHOE HARE.

Kingdom, Animalia	All animals
Phylum, Chordata	Animals with a dorsal nerve cord
Subphylum, Vertebrata	Spinal cord enclosed in a vertebral column
Superclass, Tetrapoda	Four-limbed vertebrates
Class, Mammalia	With milk glands and non-nucleated red blood corpuscles. About 4,000 species in total.
Order, Lagomorpha	Three pairs of upper incisors at birth, two pairs as adults. Includes two families, 11 genera and 65 species.
Family, Leporidae	Hind limbs larger than forelimbs, five digits on each foot. Has 10 genera and 46 species.
Genus, *Lepus*	Long ears and large hind feet. Young are born fully furred with eyes open. There are 22 species.
Species, *americanus*	Two molts each year, white in winter. There are 15 subspecies recognized including *struthopus* of the Maritime region, also introduced into Newfoundland and coastal Labrador.

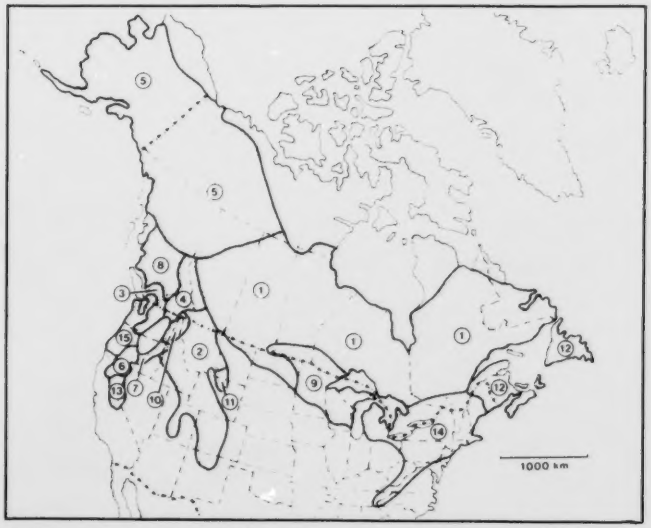
resemble each other and interbreed in nature, producing fertile offspring". The closest relatives of the species *americanus* are the other members of the genus *Lepus*. This genus includes all true hare, which are distinct from the rabbits in that the young of the hare are born in an advanced or precocial condition, fully furred, with eyes open, and capable of moving about within minutes of birth, while all true rabbits are born in a helpless or altricial state, naked and blind. Other hare include the Arctic hare, the jack rabbit and several other species around the world, most of which are found north of the equator. One close relative from Europe, the European hare, was accidentally and successfully introduced into Ontario in 1912. It was also introduced into New York state. Another, a relatively little known hare, *Lepus othus*, the Alaskan hare, overlaps the snowshoe hare range in Alaska. This hare, which is almost identical to the Eurasian mountain hare (*Lepus timidus*), is not found in Canada (Bittner and Rongstad, 1982; Banfield, 1974).

Where it occurs in North America

A precise distribution picture for any species is often difficult to establish, and so it is with the snowshoe hare. Its northern range boundary approximates the treeline of Canada and Alaska but the southern boundary is uneven. Scattered, disjunct populations occur throughout the higher areas of the Allegheny Mountains as far as Tennessee. In the northeastern states the snowshoe is found in all the mountain range areas and in occasional extensive lowland wooded areas. It is common in the northern parts of the Lake States and is found down the Rocky Mountains into Utah and New Mexico. The species also occurs southward in the coastal mountain range as far as California and Nevada.

Among the many subspecies, *L. a. americanus* occupies the most extensive range area—from western Labrador to western Alberta and south to southern Ontario and the southern areas of the Prairie Provinces. Our subspecies, *L. a. struthopus*, is native to the Maritimes and the maritime region

FIGURE 2 GEOGRAPHIC DISTRIBUTION OF LEPUS AMERICANUS



Subspecies are from Hall (1981): 1, *americanus*; 2, *bairdii*; 3, *cascadensis*; 4, *columbiensis*; 5, dalli; 6, *klamathensis*; 7, *oregonus*; 8, *pallidus*; 9, *phaeonotus*; 10, *pineus*; 11, *seclusus*; 12, *struthopus*; 13, *tahoensis*; 14, *virginianus*; 15, *washingtonii*. Adapted from Nagorsen (1985).

of Quebec east of the St. Lawrence River. It overlaps the larger *virginianus* in southeastern Quebec. Hare from Nova Scotia were introduced into Newfoundland and coastal Labrador beginning about 1864 with continued introductions for more than 10 years (Dodds, 1960a). Either *americanus* or *struthopus* was also introduced to Anticosti Island. According to Peterson (1966) it was *struthopus*, but Cameron (1958) indicates *americanus* as the Anticosti subspecies, liberated in the winter of 1902-3.

The other subspecies found in Canada are *L. a. macfarlani* of northwestern Canada, *L. a. pallidus* of central and southern British Columbia, *L. a. phaeonotus* of southwestern Ontario, southern Saskatchewan and Manitoba, and four subspecies in small range areas of southern British Columbia: *bairdii, cascadensis, pineus* and *washingtonii* (Banfield, 1974). Figure 2, adapted from Nagorsen (1985), shows the general distribution of the species in North America.

What it looks like

The snowshoe hare is larger than a cottontail rabbit and smaller than any other hare in its range. In summer it is brownish grey with a dorsal line flecked with black. There is a white spot in the center of the forehead and the feet of adults may be flecked with white while the feet of juveniles are brown. The belly is whitish in summer and the tail is white below and blackish above. In winter the animal replaces its brown-grey pelage with a white coat, but black hairs are still found along the dorsal line. Unlike the Arctic hare which has pure white hair in winter, the snowshoe's pelage is greyish near the skin, grading to white. In certain southern areas of its range the fall-winter molt results in a duller coloured fur, grading between the brownish summer coat and white winter coat of the north. This is the case, in Canada, in southwestern British Columbia. The ears of the snowshoe hare are tipped with black in both summer and winter but the black tip is more prominent in winter. The feet are covered with short, stiff hairs above and below, providing the "snowshoe" effect when the toes are spread.

Snowshoe hare usually weigh 1.4 to 1.8 kg (3 to 4 pounds) but may occasionally reach 2.3 kg (5 pounds). Comparatively, the Arctic hare weighs 3.2 to 5.4 kg (7 to 12 pounds), the European hare, in Ontario, averages 4.1 kg (9 pounds) and the white-tailed jack rabbit of the southern prairies of

FIGURE 3 SIZE OF SNOWSHOE HARE RELATIVE TO OTHER COMMON SPECIES FOUND IN CANADA

Snowshoe Hare
L. americanus
13 - 18 in.

Eastern Cottontail Rabbit
S. floridanus
14 - 17 in.

Arctic Hare
L. arcticus
17 - 24 in.

European Hare
L. europaeus
25 - 27 in.

White-tailed Jackrabbit
L. townsendi
18 - 22in

TABLE 1 WEIGHTS AND MEASUREMENTS OF FIVE ADULT NOVA SCOTIA SNOWSHOE HARE COLLECTED IN WINTER[1]

County	Sex	Total Length		Ear Length		Hind Foot Length		Weight	
		mm	inches	mm	inches	mm	inches	grams	ounces
Kings	♀							1 477	52.0
Kings	♀	467	18.4	73	2.9	131	5.2	1 572	55.4
Annapolis	♀	430	16.9	72	2.8	133	5.2	1 594	56.1
Annapolis	♀	505	19.9	78	3.1	139	5.6	1 950	68.7
Average Females		467	18.4	74	2.9	134	5.3	1 648	58.1
Shelburne	♂	444		68		123		1 370	48.2

[1]Measurements of mammals are generally consistent although there are different methods which should be clarified whenever they are presented. Total length is from the tip of the tail (skin) to the tip of the nose when the animal is placed on its back. Ear length is measured from the base of the ear notch to the tip of the skin at the top. Hind foot length is from the back of the "heel" to the tip of the longest toe (nail included in this case).

TABLE 2 WEIGHTS AND MEASUREMENTS OF ADULT SNOWSHOE HARE COLLECTED OVER TWELVE-MONTH PERIODS IN NEWFOUNDLAND

The sample sizes are in parentheses. (From Dodds, 1960a)

	Average Total Length		Average Ear Length		Average Hind Foot Length		Average Weight	
	mm	inches	mm	inches	mm	inches	grams	ounces
Female	(80)451.9	17.8	(81)71.2	2.8	(84)131.8	5.2	(80)1 647	58.0
Male	(88)458.3	18.0	(92)73.0	2.9	(92)130.7	5.1	(87)1 428	50.3
Average of Both	(168)455.1	17.9	(173)72.1	2.8	(176)131.3	5.2	(167)1 539	54.2

Canada, which is a hare, weighs from 3.2 to 5.4 kg (7 to 12 pounds). Cottontail rabbits are much smaller, weighing up to 1.1 kg (2.5 pounds) (Bittner and Rongstad, 1982; Banfield, 1974).

Weights and measurements of our snowshoe hare are somewhat less then those of subspecies to the west. All subspecies exhibit seasonal changes in weight with peaks in June and December. *L. a. struthopus* females tend to be slightly heavier than males, which is also apparent in other subspecies. Since weights and measurements are not normally published, two tables with data for our subspecies are provided, taken from a small sample in Nova Scotia (Table 1) and from Newfoundland (Table 2).

An indication of seasonal changes in colour is provided by Table 3 which reflects colour patterns of 302 adult and juvenile hare collected in Newfoundland. Although there are slight differences between molt times in our subspecies in different areas of its range, these differences are not great and the data presented are a fair reflection of what happens in Nova Scotia as well as in Newfoundland. The table shows that for five months, December-April, our hare is normally white, while during the seven months from May through October it is normally brown. Juveniles born late in the summer tend to change to white later than adults do, and all juveniles have a fluffier coat with less guard hair (outer, long hair) than the adults.

TABLE 3 COLOUR PATTERN OF 302 ADULT (Ad) AND JUVENILE (J) SNOWSHOE HARE FROM NEWFOUNDLAND

Percentage of pure white and pure brown specimens are given for each month. (From Dodds, 1960a)

Month	All White				White Dominant		Brown Dominant		All Brown			
	J	%	Ad	%	J	Ad	J	Ad	J	%	Ad	%
Jan.	2	100	5	100								
Feb.	9	100	18	95	1							
Mar.	2	100	24	69	11							
Apr.			11	41	14			2				
May								4	1	5	16	80
June									6	100	7	100
July								1	18	100	2	67
Aug.							1	1	36	97	6	86
Sept.							2	1	16	89	1	50
Oct.							15	10	11	42	6	38
Nov.	2	9	4	36	7	1	13	5			1	9
Dec.	5	83	3	100	1							

Habitat

The habitat of an animal is where it lives, including the cover, food items and water the animal uses. Good habitat provides all the requirements for an animal's existence. Some rabbit hunters and biologists refer to rabbit habitat as "rabbitat". This chapter will consider the foods and feeding first and then look at cover.

Foods and feeding habits of snowshoe hare

A species may feed upon different plants in different areas of its range since part of an animal's feeding is determined by the availability of the food plants themselves (Appendix I). Animals may select from "available" plants on the basis of palatability, which is primarily a function of taste, although the sense of smell is also involved. When rabbit numbers are very high, however, feeding pressure is very great, selection becomes difficult and the animals feed more opportunistically — that is, on whatever they can get.

In Nova Scotia snowshoe hare browse heavily on woody plants from the beginning of fall through to early spring. As spring progresses they begin to graze on the first greens available to them, increasing their use of herbaceous plant materials as the forests and forest edges "green up". During the summer their diet is primarily soft, green plant material including clover, sedges, grasses, ferns and the new green growth of hardwood shrubs and trees.

The winter food habits of grazing and browsing animals are most often studied in regions such as ours, since it is believed that food is more likely to become a limiting factor here during this most critical period of the year.

In order to better understand some of the interrelationships between deer, moose, snowshoe hare and porcupine, an assessment of the foods and feeding of these animals was undertaken in Nova Scotia in 1961. Surveys were conducted along randomly chosen lines in the different forest regions of the province and through several sites and habitats in 11 counties. It was determined that 56 different woody plant species were clipped by

TABLE 4 TEN MOST IMPORTANT WINTER FOODS, BASED ON TOTAL USE BY HARE ONLY, IN WESTERN NOVA SCOTIA (YARMOUTH, DIGBY AND KINGS)

Species	Stems	Percent Availability	Stems Browsed	Percent Browsed of Species	Percent Total Stems Browsed	PF[1]
Blueberry *Vaccinium spp.*	8406	31.2	2825	33.6	53.0	1.70
Red maple *Acer rubrum*	1140	4.2	359	31.5	6.7	1.60
Lambkill *Kalmia angustifolia*	6873	25.1	354	5.2	6.6	0.26
Yellow birch *Betula alleghaniensis*	670	2.5	350	52.2	6.6	2.64
Red spruce *Picea rubens*	755	2.8	159	21.1	3.0	1.07
Honeysuckle *Lonicera spp.*	311	1.2	136	43.7	2.5	2.08
Sweet fern *Comptonia peregrina*	939	3.5	130	13.8	2.4	0.69
Balsam fir *Abies balsamea*	1640	6.1	107	6.5	2.0	0.33
White birch *Betula papyrifera*	267	1.0	100	37.5	1.9	1.90
Speckled alder *Alnus rugosa*	268	1.0	99	36.9	1.9	1.90

[1]Palatability factor obtained by dividing percent availability into percent of total stems browsed.

TABLE 5 TEN MOST IMPORTANT WINTER FOODS, BASED ON TOTAL USE BY HARE ONLY, IN EASTERN MAINLAND AREAS OF NOVA SCOTIA (CHIGNECTO SANCTUARY, PICTOU, HALIFAX AND GUYSBOROUGH COUNTIES)

Species	Stems	Percent Availability	Stems Browsed	Percent Browsed of Species	Percent Total Stems Browsed	PF
Sugar maple *Acer saccharum*	2938	8.9	1081	36.8	22.8	2.56
Red maple *Acer rubrum*	4900	14.8	1057	21.6	22.3	1.51
Blueberry *Vaccinium spp.*	2979	9.0	543	18.2	11.4	1.27
White birch *Betula papyrifera*	572	1.7	337	58.9	7.1	4.18
Yellow birch *Betula alleghaniensis*	754	2.3	301	39.9	6.3	2.74
Rhodora *Rhododendron canadense*	3489	10.5	237	6.8	5.0	0.48
Huckleberry *Gaylussacia spp.*	551	1.7	117	21.2	2.5	1.47
Balsam fir *Abies balsamea*	2491	7.5	113	4.5	2.4	0.32
Witherod *Viburnum cassinoides*	550	1.7	106	19.3	2.2	1.29
Lambkill *Kalmia angustifolia*	5215	15.7	105	2.0	2.2	0.14

TABLE 6 TEN MOST IMPORTANT WINTER FOODS, BASED ON TOTAL USE BY HARE ONLY, ON CAPE BRETON ISLAND (ALL COUNTIES REPRESENTED)

Species	Stems	Percent Availability	Stems Browsed	Percent Browsed of Species	Percent Total Stems Browsed	PF
Balsam fir *Abies balsamea*	3582	25.8	679	19.0	20.8	0.74
White birch *Betula papyrifera*	1056	7.6	418	39.6	12.8	1.68
Beech *Fagus grandifolia*	831	6.0	258	31.0	7.9	1.32
White spruce *Picea glauca*	547	3.9	242	44.2	7.4	1.90
Speckled alder *Alnus rugosa*	405	2.9	153	37.8	4.7	1.62
Labrador tea *Ledum groenlandicum*	740	5.3	147	19.9	4.5	0.85
Black spruce *Picea mariana*	741	5.3	140	19.0	4.3	0.81
Blueberry *Vaccinium spp.*	516	3.7	134	26.0	4.1	1.11
Red maple *Acer rubrum*	523	3.8	128	24.5	3.9	1.03
False holly *Nemopanthus mucronata*	166	1.2	126	75.9	3.9	3.25

snowshoe hare during the winter (Appendix II). Probably most were eaten but it is possible that a few might have been removed in "clearing" rabbit trails or runways.

Of these 56 plants, 18 accounted for more than 75 percent of the total clipped. Among the most important woody plants for snowshoe hare in Nova Scotia, according to amounts used and relative palatability, are blueberry, white birch, yellow birch, red maple, sugar maple and spruce (white spruce especially). Tables 4, 5, and 6 (from Dodds, undated) show the 10 most important winter food items in three regions of Nova Scotia.

Regional differences showed up in Nova Scotia primarily because the availability of species differed in the regional samples. Palatability, however — which is positively correlated with nutrient levels of the plants — was always high for the birches, maples, blueberry and white spruce. On the other hand the clipping of lambkill, although considerable on the mainland, was low compared to its availability, resulting in low palatability ratings. Thus it is probable that lambkill was clipped to clear trails. Similarly, this was sometimes the case with both balsam fir in Cape Breton and with Labrador tea.

Some other woody plants are heavily used by hare but did not occur often in the sample plots at a height where they could be reached. The pines, and especially white pine, may be favoured and, as the tables show, false holly and honeysuckle may sometimes serve as rabbit ice cream as well.

When snows are deep, rabbits may browse trees that are well over 3 m (10 feet) high, but local studies indicate that most browsing occurs under 3 m and most commonly under 1.2 m (4 feet). The height at which browsing occurs varies each year with snow depths.

New growth at the tips of plants may be more palatable to all browsers than the lower, side shoots. If the snowshoe hare can reach a terminal shoot, particularly one growing at an angle, it will clip it, but terminals usually grow straight and rabbits see a plant from the side. Deer or moose, however, will often browse terminal shoots on plants under 0.6 m (2 feet) high and are less likely to browse laterals on shorter trees and shrubs. The experienced observer can normally tell the twig clipped by hare from that bitten and torn by deer or moose, since hare cut the twig cleanly and both deer and moose leave a ragged stem after feeding. Sometimes, especially on soft, new growth, it is more difficult to tell and, of course, there may be porcupine present to confuse the issue as well.

When populations of rabbits become dense — very high for a given area — they sometimes resort to eating bark. Our hare particularly like hardwood bark, but if need be they will bark pine and even balsam fir. White-footed mice and deer mice will also bark and girdle woody plants, and so will porcupine and even red squirrels on occasion. To distinguish which animal is responsible the observer has to look at the width of the incisor tooth marks on the wounded area. There may also be telltale droppings, particularly if the browser is a hare or a porcupine.

In the southern parts of their range snowshoe hare feed to a greater extent on green, herbaceous foods and, necessarily, more on woody material in the north. The number of woody plant species becomes more restricted in northern areas since diversity declines in both plants and animals as one progresses from south to north in the northern hemisphere. In Newfoundland for instance, snowshoes were found to feed on 31 species of

woody plants, just a little more than half the number used in Nova Scotia (Dodds, 1960a).

Since the nutrient content of twigs from various species has been shown to differ considerably and since rabbits are able to digest some twigs better than others, a measure of what the animals appear to eat must be compared to weight gains and losses if we are interested in food value and the condition of animals. Maintenance energy — energy for growth and for reproduction — differs for rabbits over the year. Caloric intake and nutrient needs change, so food habit studies form only one part of understanding what keeps rabbits healthy in the wild. For example, Keith et al. (1984) suggest that in winter rabbits feeding upon twigs with a diameter in excess of 4 mm (0.16 inches) cannot maintain their body weights. So when rabbits are observed browsing on thick stems and perhaps girdling the plants as well, one can assume they are not having an easy time of it.

Rabbits also need water. In summer they obtain their requirements primarily from the greens they feed upon and in winter they eat snow. In captivity, however, even when some greens are fed to them, snowshoe hare require up to 250 ml (.5 pint) of water a day (Severaid, 1945; Dodds, 1960a).

Cover

One thing almost everyone who has hunted or studied snowshoe hare agrees on is the need for relatively thick, low cover. Since a hare's defenses include concealment by blending with the seasonal landscape and by remaining motionless, it seems reasonable that it could often conceal itself better in areas of dense vegetation than it could in open areas. In thick cover the animal is also protected from airborne enemies to a greater extent than in the open. Our snowshoe hare is rarely found far out in open areas, although it may cross them to reach another cover area. It will also feed in small openings, when undisturbed, for long periods. Generally, then, it is an animal of early successional stage forest growth (following fire and cutting), an animal of relatively thick vegetation along waterways, and of alder beds, ecotones and heathlands where coniferous growth is also present.

In western Nova Scotia, Orr (1977) found that hare use began in low vegetation, with heavy use of vegetation from 3.6 m to about 11 m (12-36 feet) in height but almost no use at greater heights. He also determined that, although crown closure was a factor, the highest use occurred in patchy, white spruce regeneration where overall crown closure was under 40 percent but where patches of spruce cover were interspersed with openings of herbaceous and deciduous woody vegetation. It appears that the spruce patches provide protective cover while the openings supply the bulk of the food requirements.

In Michigan, lowland conifer-alder and upland aspen-fir-birch habitats were judged to be most important (Bookhout, 1965). White-cedar or black spruce bogs and upland spruce-fir habitats were most used in Quebec (Bider, 1961), while spruce-heath or alder-conifer and cutover regeneration with fir, spruce and hardwood between 10 and 22 years of age were important in Newfoundland (Dodds, 1960a).

Cover for the snowshoe hare thus means escape and resting cover (protective cover) as well

as feeding cover. Their "forms" or resting places are often under a spreading lower branch of an open-grown spruce or fir. In winter they may also be in an alder bed or other semi-open area where the white coat blends with the surrounding snow and only the black ear tips and eyes are picked up by the sharp observer. In Nova Scotia a combination of relatively low cover types and feeding areas makes up our bunnies' rabbitat throughout the year.

About the time that rabbit season closes in Nova Scotia one may visit a favourite alder or spruce area to find it so covered with tracks that they occur on top of each other. This sign of increased activity signals the beginning of an annual miracle which may see the spring population increase some five times or more by fall. To understand what is happening one needs to look at some of the factors that make this animal so very successful in good rabbitat throughout its range.

Breeding behaviour and parental care

Mating of our snowshoe hare is preceded by a period of courtship behaviour during which the male and female hormone levels gradually increase. The courtship behaviour pattern that develops becomes more fixed — less affected by other stimuli — as the time for copulation approaches. The stimulus to breed may be so strong that a potentially dangerous external stimulus will not evoke the fear response that allows the hare to escape. Thus, both male and female are often more vulnerable to predation during the breeding season.

The reproductive behaviour pattern develops something like this:

1. As testosterone (male hormone) levels begin to increase the male begins to react to the presence of the female, probably to a change in scent caused by a corresponding increase in female hormone (estrogen) levels. The reaction takes the form of a chase and at first the female runs away but then may stop, turn and face the male. At this time the male will either remain motionless or, early in the breeding season, may turn away to resume another, unrelated activity such as feeding.
2. As hormone levels continue to build the behaviour changes. The female, which at first might strike out at the male with her forefeet after turning to face him, will become more passive, while the male, whose fear overcame his aggression at first, becomes more aggressive. The animals may stretch their necks, at times barely touching their twitching noses when facing each other. When chasing, the male will often fail to negotiate a quick turn made by the female and temporarily lose ground or the female will jump up high, allowing the male to pass under her. Both male and female may jump and turn and the male especially may release urine at these times.
3. Eventually, when female hormone levels are high and the ripe follicles holding ova (eggs) are ready to erupt, the female will stop in a crouched position, and the male will approach and mount. Copulation only takes seconds but may be repeated several times (four times in 6 minutes, Dodds, 1960a, and eight times in 30 minutes, Severaid, 1942). Both male and female sometimes vocalize (a reasonably audible grunt or a slight squeal) during a chase and also at the end of copulation.

Since snowshoe hare may breed immediately after the birth of their young, the chasing behaviour leading up to the first breeding each year is of longer duration than the behaviour occurring later in the summer when there may be little or no chasing. The gestation period for snowshoe

hare ranges from 34 to 40 days. In Newfoundland studies it averaged 36.6 days (Dodds, 1965) and in Maine 37.2 days (Severaid, 1945).

Female snowshoe hare are very attentive to their young, called leverets. Severaid (1942) described the female's behaviour of shredding and eating the placental tissue, severing the umbilical attachment and licking the wet, young hare. Newborn hare will begin to nurse as soon as they can reach a teat, and in captivity, nursing continues intermittently for three to four weeks. In captive studies in Newfoundland females were observed on occasion licking their young for several days following birth. Females with young would often make a clicking sound when the pens were approached which would cause the young to "freeze", motionless (Dodds, 1960a). Newborn hare will move about almost immediately after birth, sometimes even before beginning to nurse.

In the Newfoundland studies the young began feeding on grass and clover provided them when 10 days old, and three young left without a mother at 22 days of age survived and maintained growth rates equal to young with their mother present (Dodds, 1960a). In another study, in the wild, a monitored female returned to the birth area and nursed its young once each day for 5 to 10 minutes just at dusk (Rongstad and Tester, 1971). This female apparently nursed its final litter of the year for more than two months, but earlier litters are normally weaned prior to the birth of succeeding litters.

Growth

At birth snowshoe hare weigh from 55 to 72 grams (1.9 to 2.5 ounces) (Dodds, 1960a). Severaid (1945) weighed 128 animals at birth and found the average weight to be 67 grams (2.4 ounces). Their growth is rapid in captivity, with average daily weight gains of 2.7 grams (0.1 ounce) (day 1) to 22.3 grams (0.8 ounces) (day 28) (Severaid, 1945). In one study leverets were gaining an average of 11 grams (0.4 ounces) per day by day 3 and continued gaining an average of 15 grams (0.5 ounces) per day up to the 44th day (Dodds, 1960a). Individuals weighed 795 grams (1.75 pounds) at 77 days, 1,363 grams (3 pounds) at 122 days and reached normal weights of wild adults at from 156 to 189 days of age. Severaid's (1945) captive hare stopped gaining weight at about 160 days. In captivity it appears that snowshoe hare reach their maximum weights at five to six months of age. It is likely, then, that they have reached their adult weights in the wild at six to seven months of age.

The breeding season

Snowshoe hare are seasonal breeders. Both male and female reproductive tracts undergo a period of regression and quiescence after the breeding season. During this inactive period the gonads (ovaries of females and testes of males) shrink as do the uterine horns of females. In late winter the gonads, accessory organs and uterine horns begin to increase in size, reaching a swollen and highly vascularized (blood-filled) condition by the time breeding begins in the early spring. In the male,

sperm cells are normally present from early to mid-March until some time in July in the Maritimes and are absent for the remainder of the year. In the female, ripe ova are present only during the greater part of the period when males are capable of successfully fertilizing the eggs.

First conception dates vary, but are really remarkably similar between years as shown by Keith and Windberg (1978) in Alberta, where the mean dates for first litter conceptions over a 15-year period (1961-76) were between March 25 and April 15. Yearly differences are apparently a function of weather, and consequently of feeding conditions which affect nutrient intake. Similarly, first conception dates do not differ markedly between geographical areas, particularly east to west, although minor differences are present north to south. Table 7 presents information on earliest and latest conception dates from several studies conducted between 40° and 50°N latitude.

But there are always exceptions. A portion of the hare present in any area may breed successfully over a much longer period, particularly during periods of population increase. In Newfoundland (Dodds, 1960a), seven "late" conceptions were recorded between October 17 and December 6. Similar records from other studies have also been noted. In Nova Scotia, occasional cases of pregnant females being shot or snared in the winter months have also been observed.

A snowshoe hare does not come into breeding condition until the spring following its birth. Thus, a hare is usually over eight months of age when it first mates. Again, however, there are exceptions. Vaughan and Keith (1980) reported that females from first litters of the year may occasionally breed at the end of the breeding season in which they were born, during the initial years of population increase.

TABLE 7 EARLIEST AND LATEST ESTABLISHED CONCEPTION DATES FOR WILD AND CAPTIVE SNOWSHOE HARE

Area	Author and Date		Breeding Date	
			First	Last
New Brunswick (wild)	Wood and Munroe	1969	March 26	July 11
Maine (captive)	Severaid	1942	March 20	July 10
Montana (wild)	Adams	1959	March 13	Early July
Newfoundland (captive)	Dodds	1965	March 26	July 8
Newfoundland (wild)	Dodds	1965	April 4	August 3
Michigan	Bookhout	1965(b)	April 3	July 3
Nova Scotia[1]	Orr	1977	March 12	No data

[1]Goat Island, Annapolis County

Litter size and numbers of young

The first litters produced each year are usually smaller than later litters. This is probably because most of the animals are breeding for the first time, and it is a general condition among most smaller mammals that the first litters produced are smaller than subsequent litters. The number of young produced may be as few as one or as many as seven; two, three and four are most common.

Although seasonal breeders, hare are polyoestrous (bearing more than once a year or having more than one "heat" or receptive period a year). When populations are increasing, the number of litters per year may increase; and in periods of decline, may decrease. From two to four litters per season are normally produced.

The number of young produced per female per year is known as the reproductive rate. It is determined by multiplying the average number per litter by the average number of litters. The reproductive rate tends to be higher in more northern range areas, and varies according to population density. That is, it may be higher when populations begin to increase. Since it is a function of both litter size and litter number, these parameters may also change between years, both geographically and in relation to population fluctuations. Table 8 presents data on the litter size, number of litters per year and reproductive rates from six studies. The Nova Scotia data are based on small samples, primarily from Yarmouth County. However, it is likely that the reproductive rate (or rates) would be somewhat lower than in Newfoundland at any given stage of population density.

TABLE 8 MEAN LITTER SIZES, NUMBER OF LITTERS PER YEAR AND MEAN NUMBER OF YOUNG PRODUCED PER FEMALE PER YEAR IN SIX SNOWSHOE HARE STUDIES

Area	Author and Date		Mean Litter Size	Number Litters per Year	Young per Female per Year[1]
Maine	Severaid	1942	2.92	2.82	8.23
Minnesota	Green and Evans	1940	2.80	2.35	6.82
Alberta	Rowan and Keith	1956	3.82	2.75	10.51
Michigan	Bookhout	1965b	2.68	2.42	6.54
Newfoundland	Dodds	1965	3.90	2.90	11.30
Nova Scotia	Wood and Munroe	1977	2.30	3.24	7.45

[1]Calculated from data presented. This figure is also the "reproductive rate" which may differ between years or between geographical areas. This figure is not the "reproductive potential" which is the maximum number of young which can be produced by a member of the species and which is a species concept that does not change.

Obviously all the rabbits that are born each year do not survive. Imagine 10 female snowshoes in your alder bed each producing 10 young next summer and all of them surviving to breed the following year. If each produced 10 and half were females, then 60 (50 + 10) females would each produce 10 the next year for a grand total of 600 rabbits, both male and female. Add the 10 males from the first spring and the 50 males produced that summer, and we would have 660 from the first spring until the end of the breeding season the following year. Another way to look at it would be that 20 rabbits became 660 rabbits in 16 months. Take it one more year, and if no animals died, your alder bed would be supporting 3,630 bunnies! From this we know that survival is not 100 percent from year to year. In fact, more little rabbits die each year than survive; many more.

Looking at populations

So what happens?

In order to find out we need some information. For instance, if animals are monogamous (one male and one female mating for a full breeding season, or for life), then a sex ratio favouring males would help guarantee that every available female had a mate, while a sex ratio with more females than males would mean that a proportion of the females would not produce. However, rabbits are not monogamous. They are promiscuous, which means that males and females tend to mate with each other as they come into contact during the breeding season, providing the female is receptive (in oestrous). If a male can fertilize the ova of more than one female, then it is biologically

advantageous for more females to be present in a population than males. Is this the case with snowshoe hares? We might think it should be, but apparently it isn't. Meslow and Keith (1968) in an Alberta study found juvenile sex ratios favouring females in only one year out of seven, which was the same year in which adult sex ratios favoured males. They also suggest that for all ages of hare, males tend to predominate over periods of time. Of course, as Bider (1961) has noted, they may also be more vulnerable, which means that we may be more likely to collect males than females. Most studies, however, have shown both juvenile and adult sex ratios to be either in balance or favouring males slightly (i.e., Adams, 1959; Newson and deVos, 1964; Dodds, 1965; Meslow and Keith, 1968). Still, when dealing with populations over extensive areas, a difference of only 1 percent could mean a great deal. An extra 1,000 females breeding in addition to a population of 100,000 females could mean 10,000 more rabbits produced. Thus, little differences can mean a lot, and therefore sex ratios are important in studying and understanding populations.

In the wild, snowshoe hare probably do not live longer than five years (Banfield, 1974). A calculated life table developed from Newfoundland data indicated only 10 hare out of 6,517 surviving until the fifth year and only one until the sixth year (Dodds, 1960a). So production is one thing and survival is another.

As soon as the first litters are produced each year, mortality begins. Mortality by sex and by age are both measured by researchers studying hare populations. When populations are declining juvenile mortality can be as high as 89 to 94 percent; it may be as low as 42 to 70 percent when populations are increasing (Keith and Windberg, 1978). This means that when populations are dropping, only 6 percent of the young may survive until winter, but that when numbers are increasing 58 percent may survive until winter. In Newfoundland, total mortality (juveniles and adults) was found to be 82 percent from one breeding season until the next, near the peak of the population (18 percent juvenile survival over year) (Dodds, 1960a).

Thus, population increases or decreases are linked closely to survival rates; differential mortality between years is responsible, to a great extent, for population changes. Generally, if we find a high proportion (75 percent or more) of juveniles among Nova Scotia rabbits harvested in November, we can assume an increasing population. But if we find less than 75 percent, or even as low as 50 percent, then rabbit numbers may be going down. Of course, one needs large samples to make reliable age determinations. In a Newfoundland study over 14,000 upper front leg (humeri) bones were collected from cooperators to obtain aging data.

What, then, kills all of those rabbits? Two major natural causes are predation and, in some instances, disease. In Alberta Keith et al. (1977) found that over 40 percent of all snowshoe hare were killed by predators in some winters — 70 percent of the total winter mortality. Brand et al. (1975), also in Alberta, lost 21 of 26 (81 percent) of their monitored hare to predation while Keith et al. (1984) noted that predation accounted for 80-90 percent of all mortality. In 1957, a sharp decline in juvenile hare in Newfoundland was linked to a disease called listeriosis (Dodds, 1965).

Other causes of death may be related to malnutrition (starvation) or increased predation

connected with malnutrition (Keith et al., 1984). It is also possible that a density-related stress disease may cause mortality (Green and Larsen, 1938) in certain instances. Accidents, such as drowning, account for the deaths of a few young hare. Human-related accidents, particularly on roads, kill a few hare in some areas.

Hunting and snaring may be the major cause of mortality in several parts of the snowshoe range in most years. This is the apparent case on Long Island, Nova Scotia. There the kill per square kilometre from snaring and hunting combined was found to vary from 19 at the apparent population low to as high as 75 during a population increase (50-193 per square mile). Natural predation is not a major factor on Long Island (Dodds and Thurber, 1965).

Other mortality may come from high parasite loads in conjunction with high hare densities, and such man-related things as accidental poisoning or the purposeful trapping and killing of hare as a means of reducing damage to gardens, reforested areas or even farm crops.

Rabbits come and go

The differences in hare productivity and survival between areas and years suggest that density differences are clearly the normal thing. Seton (1928) recorded peak densities of 36 hare per hectare (14.6 per acre), while Keith and Waring (1956) noted that hare reached a density of 23.2 per hectare (9.4 per acre) at peak levels. These figures mean 3,608 hare per square kilometre (9,344 per square mile) in Seton's case and 2,323 per square kilometre (6,016 per square mile) in the case of Keith and Waring's estimate, which may be the more accurate of the two. At a low point, Keith and Windberg (1978) reported a density of 0.7 per hectare (0.3 per acre) or 74 per square kilometre (192 per square mile). It is likely that in moderate to poor habitats in Nova Scotia densities are not nearly so great either for the "high" or the "low", but densities of 200 to 400 and more per square kilometre (500 to 1,000 per square mile) probably occur commonly during peak populations.

Probably no animal population cycles have undergone more study than the microtine (small rodent) and snowshoe hare cycles, yet these population changes are really not cycles at all because the high points are not predictable. Perhaps it would be more accurate to refer to these changes as fluctuations. Charles Elton of the Bureau of Animal Populations at Oxford University began a systematic accounting of snowshoe hare increases and decreases across Canada, including Nova Scotia, in 1931 (The Canadian Snowshoe Rabbit Enquiry). Prior to that, hare fluctuations in Canada had been recorded or inferred through Hudson's Bay Company records of lynx and hare fur shipped from Canada and the 1925-26 enquiry carried out by Hoyes Lloyd of the then National Parks Branch. Seton and other naturalists had also brought the "cycle" to the public's attention in the 1920s. Since then dozens of researchers have published works on the great rabbit-lynx cycles and their causes.

The lynx, strongly dependent on the snowshoe hare, was and is less of a problem to understand, but what about the hare? Suggested causes for its "cycle" range from food (Grange, 1949) to sunspots (DeLury, 1931). The first important scientific paper on the subject was Duncan MacLulich's 1937 paper

entitled "Fluctuations in the numbers of the varying hare" published by the University of Toronto. Today we know that hare fluctuations do exist, with high points averaging 9.7 years apart (8 to 12 years).

Hare fluctuations also differ in amplitude, with greater variations in numbers and densities occurring in the north and relatively little variation occurring in the southern range areas. "Cycles", although generally in phase regionally, may also exhibit local differences. Rabbit hunters in Nova Scotia know this. According to information presented in the "Snowshoe Rabbit Enquiry" publications, portions of Nova Scotia had peak hare populations in 1931-32 and again in 1939-41. On Long Island, Digby County, Dodds and Thurber (1965) indicated probable peaks in 1950-51 and 1960-61. Data collection was continued after 1965, revealing another probable peak in 1969-70; after this the study lapsed.

We have considered the causes of death in hare, and it is to these causes that we must look, as well as to the reproductive changes also referred to, for our explanation of "cycles". Hare populations increase rapidly when densities are low, but density-dependent mortality increases immediately following the increase in hare numbers. Predation in conjunction with malnutrition seems to explain the Alberta "cycles" studied, while other population stress factors such as parasites, disease and human harvests are probably involved elsewhere. In Nova Scotia a combination of natural predation (lynx, bobcat, coyote, black-backed gull, owl, etc.) and human harvest, along with malnutrition at high population densities, probably interact as in Alberta to cause declines.

Island populations may "behave" quite differently than continuous mainland populations. Islands tend to have fewer mammalian species since colonization is restricted to those mammals capable of moving across water or hitching rides on ice or floating debris. Good colonizers must be capable of moving fairly long distances and must also be able to go without food for a time and/or to utilize available foods very efficiently. Zoogeographers have indicated that the closer the island is to a mainland area, the more species it is likely to have. Similarly, the larger the island the greater the probable number of species. Thus, islands many miles from mainland areas — such as Sable Island — are not rich in mammalian fauna, while many coastal islands along Nova Scotia's shoreline have several species present.

Since islands prevent movement away at high population densities, mammals are restricted to the food and cover available in an ecologically defined area. Population increases may result in crashes to levels so low that they may not recover. Snowshoe hare, for example, have been introduced to many islands around both Nova Scotia and Newfoundland by local people, particularly fishermen, who would set a few snares and tend them when returning from their fishing grounds. This was the case with several islands in Placentia Bay, Newfoundland, and over periods of a few years the hare numbers would peak and crash, often leaving no animals. Nutrient intake levels and avian predation might well be involved in such instances, as well as disease. Populations of snowshoe hare on small islands allowing no egress are particularly unstable and often reflect quite different fluctuations from even nearby mainland populations.

All of this productivity leading to near regular high density populations is part of an evolutionary process that is related to other animals as well. The snowshoe hare provides the fuel to run a part of a large and complex "eco-machine". Our rabbit is a first level consumer — feeding on plants — and because of its size provides much of the energy for several species of mammalian and avian predators within its range. For it is the number and the biomass of prey organisms that determine the density and species of predators. It is sometimes true that predators serve as a control on prey numbers but the reverse is always true.

"Rabbit fuel"

Predators feed upon prey species in relation to prey size and prey availability. That is, as a general rule, large predators tend to feed more on large prey and small predators feed on smaller prey. Wolves may utilize caribou or deer and use hare only occasionally, while coyotes may kill deer but use hare far more often, or even for a time exclusively. Foxes, on the other hand, may eat voles to a great extent where they are plentiful and use hare less often.

Although it is obvious that there is considerable variation in the size of the prey a predator can kill, the predator usually kills the species that allows for the greatest efficiency in relation to energy expended to obtain its food, versus energy obtained by eating it. This energy efficiency ratio is closely related to the availability and abundance of prey as well as to prey size. Although the size of a single hare may offer more energy for a fox than a single vole, if voles are numerous and easy to catch the fox may well concentrate on the smaller prey. Similarly, in times of hare abundance, coyotes may kill many hare and few, if any, deer.

Some predators are known as diversified or opportunistic feeders in that they feed on a great diversity of prey, killing each species as the opportunity presents itself. Other predators may feed on one species more than any other and use only a few species in total. These latter animals may also be less opportunistic in that their hunting behaviour and, often, their body form and development, restrict the opportunities they have to kill and feed on other than their "target" species. The lynx is such an animal. Its hunting behaviour allows it to "target" the snowshoe hare, and because of the habitat the hare occupies, as well as the searching behaviour of the lynx, few animals of other species may be taken.

In various areas of snowshoe range, hare provide an important part of the diet of lynx, bobcat, red fox, coyote and horned owls. In some cases, the hare may be the most important prey item maintaining the predator population, such as with the lynx. Hares may also provide a part of the diet for barred owls, goshawks, red-tailed hawks and wolves. In a few cases, depending upon the location and numbers of hare, snowshoes may be important to black-backed gulls or eagles and, although hardly important in their diets, domestic dogs and cats may also kill hare commonly.

The snowshoe hare's "niche", then, is that of a medium size mammalian prey species occupying relatively dense vegetation under 12 m (40 feet) in height. Without the snowshoe hare many predators would necessarily exist in much lower numbers, and in some instances certain predators would not exist at all. In Canada's Atlantic region we have many examples of the importance of snowshoe hare as fuel in predator-prey "eco-machines". Newfoundland lynx digestive tracts contained snowshoe hare in 69 percent of the samples collected in the winter and early spring (Dodds, 1960a), while small bird remains were found in only 11 percent and moose (carrion) in 8 percent. While all lynx were found to be highly dependent on hare throughout Newfoundland, red foxes living in barren areas where snowshoe hare were not present depended largely upon meadow voles (*Microtus pennsylvanicus*): 100 percent of scats examined held voles while 29 percent of the scats

showed small bird remains (Dodds, 1960a). On the other hand, foxes living in forested areas of central Newfoundland used both snowshoe hare (48 percent of scats examined) and small birds (42 percent) in summer months. Moose carrion (8 percent of the droppings), meadow vole (2 percent) and muskrat (2 percent) were of lesser importance (Dodds, 1955). Again in Newfoundland, Saunders (1963) found snowshoe hare occurring in 73 percent of all lynx digestive tracts taken throughout the year, with small birds in 21 percent and meadow voles in 14 percent.

In the highlands of Cape Breton, Parker (1981) found that lynx preyed almost exclusively on snowshoe hare in winter (198 of 200 chases and 34 of 36 kills). He also estimated that each lynx consumed an average of one hare per day. If there were 160 days of snow cover and 300 lynx throughout the entire highland area, this would mean 48,000 rabbits would be killed by lynx alone. Of course, we don't know if there were 300 lynx there but the figures do give us food for thought. It takes a lot of bunnies to fuel the machine.

In Newfoundland, Saunders (1963) determined that each lynx killed a hare every 48 hours. An estimated population of 5,000 lynx for the entire island (about 116,550 km^2 or 45,000 square miles) would not have been too high for the mid-fifties when Saunders conducted his study, and if there were 160 days of snow cover, a possible 400,000 rabbits (times 3.4 pounds per rabbit = 680 tons) might have been eaten. Then, too, as we have noted, rabbits are also prey in spring, summer and fall!

A total of 1,099 Nova Scotia wildcat stomachs were examined by Matlack (1984) out of carcasses collected by the Nova Scotia Department of Lands and Forests from trappers throughout the province. The animals were taken during the fall-winter trapping seasons of 1980-81 and 1981-82. Snowshoe hare was found in 71 percent of the stomachs containing food, and they provided 81 percent of the total food volume. White-tailed deer occurred in 18 percent of the stomachs and provided 12 percent of the food volume. Although small mammals and birds were also taken, they only accounted for about 7 percent of the total food volume. Clearly, the snowshoe hare is the animal that keeps the cats going in Nova Scotia.

When snowshoe hare are plentiful, predators take more of them. Both Matlack (1984) and Parker and Smith (1983) found such trends in Nova Scotia. When hare numbers decline, the proportion of other prey such as small mammals and birds or, sometimes, deer increases slightly in the diets of cats. Sometimes, when rabbit populations crash, dependent predators move great distances. Such movements of lynx, horned owls and wildcats to more southerly areas have been recorded several times since 1900.

In recent years, coyotes have moved east into Nova Scotia and Prince Edward Island. The coyote, as an opportunistic feeder, will also put pressure on snowshoe hare and white-tailed deer, both important food items for coyotes in New Brunswick where rabbits were found in 32 percent and deer in 25 percent of the coyote stomachs collected between 1979 and 1981 (Moore, 1981).

Rabbits and other animals
(Coactions)

Rabbits don't exist alone in the forests. We've noted that fact by recognizing their importance as prey for several predators, but the coactions or interrelationships between two or more species can often be very complex. Usually these relationships are quite subtle and it is only through rather intensive research that they are understood. One of the more fascinating examples of the snowshoe hare's relationship with other species is now apparent to us through hindsight. It concerns the introduction of snowshoe hare to Newfoundland.

Snowshoe hare were introduced from Nova Scotia to Newfoundland outport communities through local magistrates, beginning about 1864. The introductions continued, starting in the east and some southwest coastal communities and extending around to the northeast, north and west coasts, over a period of several years. The first peak densities of hares occurred in eastern Newfoundland around 1900, and this peak was immediately followed by the first high density lynx population. Lynx were present as indigenous predators in Newfoundland but in the absence of snowshoe hare had existed only in very low numbers. Without our rabbit their productivity apparently remained low, and they remained a scarce animal, feeding on a few Arctic hare, caribou calves (Bergerud, 1971), small birds, voles and other prey. Without the snowshoe hare, which had co-evolved with lynx, the lynx did not do well; but as soon as our transplanted Nova Scotia hare increased, the lynx, feeding on its real target species, became prominent.

What happened when the hare numbers crashed, however, is fascinating. Since Newfoundland lynx had previously existed partly on Arctic hare and caribou calves, the now large numbers of lynx preyed upon these animals again when the hare were no longer available. This happened once during each lynx-hare "cycle", resulting in the elimination of Arctic hare in all but true barren, boulder-strewn areas uninhabited by lynx and resulting as well in a control on the caribou population. Indirectly, our rabbit had become the animal responsible for startling declines in both Arctic hare and caribou. Who would have predicted this?

Of course, there may also be competitive interrelationships with other herbivores as well. For instance, competition for food may occur between snowshoe hare and moose in balsam fir-white birch cutover areas of Newfoundland (Dodds, 1960b). Bookhout (1965a) found that snowshoe hare and white-tailed deer on Michigan's upper peninsula compete for willow, white birch, red maple, alder and shadbush. In Nova Scotia, deer, moose, porcupine and snowshoe hare all browse in our forests. When populations of hare are very high, it may well be that their nutrient intake levels are reduced partly because of the feeding effects of one or more of the other animals.

Snow depth and surface compaction as well as the height of vegetation become part of this coaction complex, as do air temperatures and exposure. In the final analysis competition for food becomes a matter of energy balance for each browser. As long as the energy intake equals the output our bunnies are okay.

Home range, movement and activity

The home range of an animal must provide all the necessary requirements for the animal to live. In good habitat, then, the home range for snowshoe hare will be smaller than it may be in poor habitat where hare will have to range farther to obtain their requirements. It is also true that juveniles are more sedentary, occupying smaller home range areas than adults. In various tagging studies, and in recent years with radio telemetry, snowshoe hare have been found to occupy home ranges from 5.9 ha (14.8 acres) to 13 ha (32.5 acres) with females and juveniles often using less total space than males. With few exceptions distances moved are prescribed by the home range, and as many hunters know, snowshoe hare can move a great deal, circling within this 6- to 13-ha area or even within smaller confines. Occasionally, however, rabbits will move considerable straight-line distances (a kilometre or more), especially males when breeding season approaches or, sometimes, when pursued by a beagle.

Snowshoe hare are most active during early evening and early morning hours. During the initial courtship behaviour period in the late winter, activity increases and may be almost continuous throughout the night. Juvenile hare, too, may feed for greater periods of time than their parents, often through mid-morning during the spring and summer months. As with many mammals, high winds will tend to reduce hare activity, and in winter hare sit fairly tight during storms, often for one, two or three days. When this happens, the hare will feed for longer periods than usual after the storm has abated. Rabbit hunters in Nova Scotia know that activity will be high after a few inches of snow have fallen!

Miscellaneous behaviour

Although snowshoe hare are apparently not strongly aggressive, they may fight, jumping at one another face to face and scratching with the sharp nails of their forepaws or occasionally biting (Grange, 1932). This aggression is exhibited by males and is most common during high densities (Windberg and Keith, 1976). As noted previously, however, the female may show considerable aggression toward the chasing male at the beginning of courtship behaviour. This aggression is not repeated during succeeding matings throughout the breeding season.

To escape predators, hare will run, sometimes following their paths or runways but occasionally running across openings to areas of cover and abandoning their runways altogether. Their running may be interrupted by short rests depending upon the closeness of the predator. At other times, a hare will crouch motionless until the predator attacks. When caught, the hare may scream loudly. Running, "freezing" and screaming are all fear responses, and all have survival value in that, although many hare are caught, a few escape. Even the scream may surprise the predator for an instant, allowing the prey a split second's advantage.

The hare's defense is in numbers. The individual hare is expendable. Ecologists refer to prey species that depend on their reproductive

capacities to keep their populations intact as "r-selected species", while animals with low reproductive potentials that have special survival abilities related to their feeding and behaviour are known as "k-selected species". Our bunnies are clearly r-selected.

Besides their runways, which are clipped clean by the rabbits using them, our hare also use "forms" where they rest. The same form may be used repeatedly and its location is usually in a place that allows for rapid escape (with the first jump of several feet).

Snowshoe hare, like many other lagomorphs, re-ingest certain partly digested "green pellets" by re-chewing them; this behaviour is called coprophagy. The regular brown (or blackish if from nursing young) pellets are dropped singly or in strings while moving, feeding or immediately following rest. Thus, their trails are strewn with pellets, and when populations are high the animals may hop along on a bed of pellets by the end of the winter.

Hare groom themselves by licking their fur and by biting to relieve annoyances caused by their many parasites. They scratch with their long hind feet and may use dust baths not unlike those of ruffed grouse. Hare are also curious and will often stand almost erect to see better or to smell a passing scent more effectively. They will also stand to reach succulent twigs or leaves.

The snowshoe hare's senses are well developed. Its sense of hearing is especially acute, its sense of smell is sharp and even its ability to see is particularly good. It is an animal blessed with keen senses but not blessed with exceptional escape abilities.

A hare communicates through its sense of smell, through vocalization — especially during breeding and the rearing of young — and sometimes by stamping its hind feet on the ground. Communication is related either to breeding and care-giving behaviour, especially nursing, or to escape behaviour such as a warning to freeze or to flee.

On occasion hare will swim, but this is not a usual practice, and swimming has been observed most often when the animals are being pursued. They are not good swimmers, and their fur is not dense enough to protect the skin from the water, but as in other terrestrial mammals, swimming is a possibility, if necessary.

Parasites and Diseases

A parasite is a small organism which, at some stage of its life cycle, lives on or in a larger organism (host) and which may cause some harm to the host. "Successful" parasites seldom kill their hosts, since the host provides the environment and the nutrients for the parasite. Indeed, the evolution of parasite-host relationships provides examples of complex co-evolutionary patterns which, in some instances, change over time from lethal parasitic situations to positive symbiotic relationships where either the parasite is benefitted without major host damage or where both parasite and host are benefitted. Often parasites cause considerable damage to "new" or alternate hosts, but passing generations effect a degree of compatability allowing for near 100 percent host survival.

Parasitism may be a secondary problem, however, contributing to death in juveniles and in animals suffering from malnutrition or disease. In Nova Scotia, for instance, the moose tick *Dermacentor albipictus* was often found in massive infestations on moose that were dying from another cause, the brain worm. As the moose became weaker, it could not rid itself of the pests and was soon covered with ticks obtaining the "blood meal" necessary for their survival. Parasites may effect control on host populations but normally they do not. In fact, as with predators and prey, it is the density of the host that often determines the density and frequency of occurrence of parasites.

Diseases are pathogenic conditions usually caused by viruses, fungi, bacteria or rickettsial organisms or, sometimes, by larger parasites. Sometimes external parasites carry a bacterium or a virus which is introduced into a host during the external parasites' feeding. Diseases often do control mammal or bird populations, and some may also be dangerous to humans as we will note.

TABLE 9 PARASITES OF SNOWSHOE HARE, COMMON LOCATION, INTERMEDIATE AND OTHER DEFINITIVE (ALTERNATE OR RESERVOIR) HOSTS

* Likely to be found in or on Nova Scotia hare

INTERNAL OR ENDOPARASITES	INTERMEDIATE HOSTS	OTHER DEFINITIVE HOSTS
Trematoda (Flukes)		
Dicrocoelium dendriticum (liver)	snails, ants	sheep, woodchucks, European rabbit, cottontail rabbit
Nematoda (Roundworms)		
**Obeliscoides cuniculi* (stomach)	direct life cycle	
**Trichostrongulus calcaratus* (cecum, large intestine)	direct life cycle	
**Trichostrongulus affinis* (cecum, large intestine)	direct life cycle	
**Nematodirus triangularis* (small intestine)	direct life cycle	
**Passalurus nonannulatus* (small intestine)	direct life cycle	
**Dirofilaria scapiceps* (hock joints)	mosquito	
**Protostrongulus boughtoni* (bronchi, lungs)	possibly snails	
Trichostrongulus axei (stomach)	direct life cycle	sheep, horses, some ruminants
Strongyloides papillosus		
Trichuris leporis (cecum, large intestine)		
Cestoda (tapeworms)		
**Cittotaenia* (*Mosgovoia*) *pectinata* (intestine)	indirect	
**Taenia pisiformis* (mesenteries, tenderloin)	larvae in hare	foxes, other canids
**Hydatigera taeniaeformis* (mesenteries, tenderloin)	larvae in hare	lynx
**Multiceps* (*Taenia*) *serialis* (mesenteries, muscle)	larvae in hare	canids
**Taenia macrocystis* (mesenteries, tenderloin)	larvae in hare	lynx, wildcat, other cats
EXTERNAL OR ECTOPARASITES		
Siphonaptera (fleas) unimportant but occasionally recorded		
Hoplopsyllus glacialis		
Monopsyllus vison		
Ceratophyllus garei		
Spelopsyllus cuniculi		
Acarina (ticks and mites)		
**Haemaphysalis leporis-palustris* (all over, but head and ears extensively)	small mammals (nymphal & larval stages)	other lagomorphs
Dermacentor variabilis occasional		
Dermacentor andersoni occasional		
Trombiculidae and **Parasitidae** (families of mites) probably unimportant. Lice may also be present on occasion.		

[1] Since the systematics of these animals is changing, scientific names may differ from some used in other publications.

Snowshoe hare parasites

Most smaller herbivores have lots of parasites, and the rabbit is no exception. Table 9 lists the most common snowshoe hare parasites. Those most likely to be found in our rabbits are marked with an asterisk. Table 10 has been taken from *Snowshoe Hare in Nova Scotia* by Neil van Nostrand, and it lists worm or helminth parasites found in 94 rabbits collected in 12 counties of Nova Scotia in 1967 and 1968. The common stomach worm, *Obeliscoides cuniculi*, was found in 87 of the 94 hare (92.5 percent). In Newfoundland this worm was found in 67 percent of 431 hare examined, but regionally the infestation rate reached 88 percent (Dodds and MacKiewicz, 1961).

TABLE 10 INCIDENCE AND DISTRIBUTION OF WORMS FOUND IN 94 RABBITS TAKEN IN TWELVE COUNTIES IN NOVA SCOTIA DURING FALL AND WINTER 1967-68[1]

Numbers refer to the number of rabbits found to be infected.

County	Number of rabbits examined	*Obeliscoides cuniculi*	*Trichostrongylus calcaratus*	*Trichostrongylus affinis*	*Nematodirus triangularis*	*Passalurus nonanulatus*	*Dirofilaria scapiceps*	*Protostrongylus boughtoni*	*Cittotaenia pectinata*	*Cysticercus* species	*Dicrocoelium dendriticum*
Yarmouth	6	6	5	6	4	1	0	1	0	3	0
Shelburne	5	5	2	5	5	1	0	4	0	1	0
Digby	1	0	1	0	0	0	0	0	0	0	0
Lunenburg	14	13	7	9	10	2	7	6	0	5	0
Kings	11	9	4	3	6	0	7	4	0	5	0
Hants	4	3	3	3	0	0	2	1	0	0	0
Cumberland	16	14	3	12	11	2	11	10	0	4	0
Colchester	6	6	2	2	0	1	0	5	0	4	0
Pictou	7	7	6	6	6	3	3	4	0	1	0
Guysborough	13	13	7	9	10	1	0	5	0	6	0
Antigonish	6	6	4	5	5	4	0	3	0	1	0
Cape Breton	5	5	4	2	0	2	0	5	1	1	0
Total	94	87	48	62	57	17	30	48	1	31	0
% Infected	100.0	92.5	51.0	65.9	60.6	18.0	31.9	51.0	1.0	32.9	0

[1] Information provided by Dr. Harry Smith, Pathology Division, Canada Department of Agriculture, Sackville, New Brunswick. From van Nostrand (1971)

Parasitism is a density-dependent occurrence and is positively correlated with the populations of the hosts. In the case of the stomach worm the life cycle is direct, meaning there are no intermediate hosts required. Eggs are shed in droppings and hatch into larvae which are mobile in moist vegetation normally eaten by the rabbits. The chances of transmission, then, increase proportionately to the hare population. This most common internal parasite normally goes undetected by rabbit hunters since it is not easily observed when the animal is being cleaned. In order to see it, one needs to cut the stomach wall and remove the contents. The worms will lie in the mucous lining of the stomach or against the matted food. It is unlikely that this worm is harmful to otherwise healthy rabbits, and if eaten by humans it would also be harmless.

There are common internal parasites which rabbit hunters and rabbit catchers do see regularly. The most common of these are the "bladder worms" which are larval stages of adult tapeworms of the mammalian predators of rabbits. They are usually found in whitish, bladder-like sacs in the mesenteries and connective tissue of the intestines and throughout the internal body cavity. They may also lie, elongated, beneath the tenderloin muscle along the backbone. They are seldom embedded in the surface tissues of organs themselves. One species in Nova Scotia is *Taenia pisiformis*, the rabbit-dog tapeworm, while the other is *Taenia macrocystis*, a rabbit-cat tapeworm (van Nostrand, 1971). The most likely definitive hosts for the adult worm are foxes and wildcats respectively. In each instance, the eggs are dropped in the predators' feces and hatch into larvae which are eaten by rabbits with vegetation, and then the rabbit is eaten by the predator, in which the adult worm develops. It is probably not wise to allow your beagle hound to eat rabbit "guts" or whole rabbits. In fact, if they eat the rabbit at all it should be after the "innards" are taken out! Even then there is a chance of infecting the dog since these "bladders" may not be completely removed when the rabbits are cleaned. It is also possible that anyone who has eaten rabbit may have also eaten the larvae, but there is no cause for concern since these parasites are host specific; that is, they will infect and develop only in the species, genus or family that they have evolved with — in these cases, dogs (canids) or cats (felids). Of course, you also eat the rabbit only after it is cooked!

Other common parasites are found in the digestive tract or body organs or, occasionally, in skeletal joints or muscle tissue. None of these parasites is harmful to humans, so a knowledge of them should not dissuade you from eating rabbit.

By far the most common ectoparasite is the rabbit tick *Haemaphysalis leporis-palustris*, which occurs as an adult — particularly about the head region of a hare — and as both larva and nymph anywhere on the body. Other small mammals are often more important for larval and nymphal stages, however. These ticks are not present after the first heavy frosts of fall. Adults spend the winter dormant in ground litter.

Ticks are "negatively geotropic", that is, they ascend toward the tips of vegetation, away from the earth's surface in spring and attach themselves to rabbit fur as the host brushes by. The male and female tick both engorge with blood, but the armor of the male prevents it from reaching the large size of the blood-filled female, which requires the blood for her eggs. Eggs laid on the ground

hatch into six-legged larvae which also ascend low vegetation and attach to a passing mammal host on which they feed. After feeding they drop off the host and moult into eight-legged nymphs which again ascend vegetation, attach to hosts, feed and moult into eight-legged adults.

Since this tick is a known vector of tularemia, as well as other bacterial and viral diseases, it is of considerable importance in certain portions of its range. Where tularemia is known to be present, seasons on rabbits and hare are not opened until well after frost has allowed the potential vectors to drop off for the winter. This applies to muskrats and beaver as well, both of which are also susceptible to the disease.

The total number of parasites in or on a single hare may be very great when populations of hare are high and just after peak densities have passed. Bookhout (1965a) found a maximum of 171 adult rabbit ticks on one hare with an average of 23 per hare while the average number of all three stages of tick per hare was 556. This is really nothing compared with the average of 4,911 per hare reported by Green and Shillinger (1934) in Minnesota! These figures are doubtless higher than any we are likely to find in Nova Scotia or, perhaps, in Atlantic Canada. The largest number of adult ticks per hare found in Newfoundland, for instance, was only 28 (Dodds and Mackiewicz, 1961). Other numbers from Bookhout (1965a) in Michigan are, for the common stomach worm, a high of 1,591 in a single hare, and the rabbit pin worm, *Passalurus nonanulatus*, a high of 5,325.

Diseases of snowshoe hare

Among the diseases that may be present in snowshoe hare are several caused by viruses, bacteria, fungi and rickettsial agents and two other conditions known as "shock disease" (Green and Larson, 1938) and "trap sickness" (Adams, 1959). These latter conditions have been associated with either extremely high densities or confinement, and seem to be "psycho-physiological" in nature.

There are several viral and rickettsial organisms that have been reported in snowshoe hare. Two of them, California encephalitis and silverwater, are most persistently active in snowshoe hare (Bittner and Rongstad, 1982). The most important fungal condition is ringworm caused by the fungus *Trichophyton mentagrophytes*, first reported by Adams, Salvin and Hadlow (1955) in Montana, but which has not been reported here. There are at least 17 bacteria infecting hare (van Nostrand, 1971), of which tularemia caused by *Francisella (Pasteurella) tularensis* was first reported in snowshoe hare by Green, Larsen and Bell in Minnesota in 1939. This bacterium can become epizootic (epidemic) in several species of rodents and lagomorphs and has been known to decimate populations of muskrat and cottontail rabbits. It has not been known to affect snowshoe hare greatly and has never been reported in hare in Nova Scotia. According to van Nostrand (1971), two cases of tularemia in humans were reported from Cape Breton Island's Richmond County in 1935, but no further evidence of the disease has been recorded. Nevertheless, since tularemia can be lethal, care should be taken. The appearance of white flecks in the liver, caused by any of several

bacterial conditions, should be treated with caution. In most instances the rabbit will not have tularemia, but it always pays to be safe. Perhaps the simplest safeguard would be to avoid dressing out rabbits if you have open cuts on your hands, since other bacterial infections can sometimes be a bother too.

Another bacterium, *Listeria monocytogenes*, a disease of at least 27 wild and domestic animals, may have been responsible for high mortality among juvenile hare in Newfoundland (Dodds and Mackiewicz, 1961). This organism has not been reported in Nova Scotia rabbits, although there have been rare instances of humans and captive mammals having the disease (McKercher and Archibald, 1959).

For some 15 years during the 1960s and 1970s, cooperative studies were conducted from Acadia University in Wolfville on the "dog tick", *Dermacentor variabilis*, in Nova Scotia. Part of the interest in this tick was initiated by the knowledge that it was a known vector elsewhere of Rocky Mountain spotted fever (RMSF). The etiologic or causative agent of RMSF is *Rickettsia rickettsia*. Although antibodies of *R. rickettsia* have shown up in sera of guinea pigs inoculated with suspensions of adult *D. variabilis* and sera of *Lepus americanus* as well as sera from some birds in southwestern Nova Scotia (Campbell, Ward and Garvie, 1980), no cases of RMSF have ever been documented in this province. A less harmful organism than *R. rickettsia*, known as *Coxiella burnettii*, the causative agent of Q fever, may be established in both *Haemaphysalis leporis palustris*, the rabbit tick, and our snowshoe hare; however, we should not be overly concerned since Q fever is normally an innocuous condition which may go undetected. Slight skin rashes and slight temperatures may occur in humans with Q fever.

What Are Rabbits Worth?

We already know they are worth a great deal for, as we have previously indicated, without our rabbits our many medium size predators would not be nearly as plentiful. Even if there were no other plus factors, their high ecological and biological values can be seen to be very important. There are other values, however, both positive and negative.

Snowshoe hare have served as an important food for man in this region for thousands of years. Prior to European contact, indigenous peoples included rabbits in their diets. Smith (1919) (*in* Nash, 1980), found rabbit remains at Merigomish, Antigonish County, along with the remains of bear, moose, deer, dog, raccoon, woodchuck, porcupine, beaver, muskrat, squirrel, whale, seal, walrus, birds and fish. Erskine (undated) excavated a site dated in the 1300s at Port Joli, Queens County, where rabbit bones were present in 35 percent of the sample squares. He felt that shellfish and rabbits were work and "game" for women and children and that rabbits were only killed in winter. This particular site, incidentally, was estimated to contain 169 tons of shells!

Following European contact the rabbit became a staple for French and English trappers throughout the settlement period, used as food for both dogs and people. It has remained a staple food item for humans in some parts of Canada right up to the present. Snowshoe hare were used in the fur industry for many years, the fur being made into linings of gloves. During the heyday of the Canadian silver fox industry of the 1930s, rabbits were used as fox food. According to Sara (1936), in southern Alberta "an increasing demand for rabbits by the fox ranches, locally, has developed quite a winter industry, particularly around Bragg Creek, which was shipping out approximately a

ton of rabbit carcasses each 10 days during winter months" (*in* Elton and Swynnerton, 1936). And from Yarmouth, Nova Scotia, Burrell (1942) noted, "Fur farmers have been buying rabbits the past three winters, and in cold storage for fox and mink food there were 2,903 pounds at the end of March, 1940" (*in* Chitty and Chitty, 1942). Obviously, snowshoe hare were important to the fur farming industry and it seems likely that foxes were "wormy", although parasite larvae may well have been killed when carcasses were frozen.

Today's values in Nova Scotia

Besides the ecological values of rabbits as a prey species they also have recreational, economic and esthetic values. Recreational values are not always easy to measure, and in the case of rabbits, where many are sold and most others are eaten by the hunter's or rabbit catcher's family, the indices one might use are clouded by economic values. For instance, in 1984-85 over 171,000 rabbits were snared in Nova Scotia, and probably most of the rabbits sold were from this group. In addition there were over 160,000 shot without the aid of dogs, and almost 90,000 shot with the aid of dogs. Probably most of the expenditures and time spent to obtain this latter group (with dogs) could be accepted as indices of recreational value. But the portion of time and effort for the other two groups which we might deem "recreational" or "economic" would be highly subjective. Still, the total of 421,388 rabbits harvested means that they were responsible for thousands of hours of recreation and thousands of dollars in income to hunters and rabbit catchers and their families. In fact, rabbits comprised 77 percent of the total number of upland game mammals and birds harvested in Nova Scotia in 1984-85 (421,388 out of 546,515 for all animals), or more than three times the total of all other upland game species together (grouse, pheasant, woodcock, snipe and Hungarian partridge) (F.C. van Nostrand, Upland game and furbearer biologist, personal communication, September 3, 1985).

In addition to the income to people who sold rabbits and in addition to the meat value, there were expenditures made in order to pursue and catch these rabbits. Although we might be able to put "ball park" dollar estimates on income and expenditures, we do not have the socio-economic data to permit us to make really reliable estimates concerning these recreational and economic values. Still, even a very conservative figure of $2.00 per rabbit as a value for the meat (sold or consumed by the hunter), the expenditures (shells, gas, etc.) and the recreation time means that rabbits are worth a million dollars a year to Nova Scotians, much of which enters the market economy. To some people the little additional income generated or food provided is of great importance. Of course, many school children also benefit from catching and selling a few brace of rabbits each year.

Although not in the direct income-generating area, there are also expenditures for dogs, guns, dog food, veterinary expenses and clothing which may be indirectly related to hunting rabbits. In some cases these expenditures are specifically related to hunting rabbits. In 1984-85 there were 2,810 people who hunted rabbits only (van Nostrand, personal communication) so that all of their hunting expenditures were made because of

an interest in the lowly bunny. Harvest records for three regions of Nova Scotia — west, east and Cape Breton — are presented in Table 11.

For thousands of Nova Scotians, snowshoe hare are animals to be enjoyed when viewed along roadsides or in backyards as they feed in the evening or early morning. Of all our wild mammals the rabbit and the red squirrel are the ones most often seen along our roads. For many they provide one of the few contacts with wild animals. It is easy for most people to identify with the snowshoe hare since the hare or rabbit has been presented to children and adults in books, movies and on television as a friendly little family person (Peter Cottontail) or as a clever prey escaping the dull-witted predator. The bunny family of cartoons, and many anthropomorphic, quasi-natural movie and television productions, has been indelibly etched in television viewers' minds, so seeing them in the wild may be just a little bit special. Esthetic values are very important but difficult to measure; however, each little bit of therapy provided by watching rabbits is both spiritually and physically beneficial.

Values elsewhere

Snowshoe hare are used for food throughout much of their Canadian range and are legally hunted and/or snared in all Canadian jurisdictions. They are still used for trap bait, dog food and human food in both outport and inland communities north to the treeline. As a sport animal, the snowshoe hare has a better image in the southern areas of its range and closer to urban areas than in the north or in rural sections of the country. In the United States the snowshoe hare is doubtless more prized

TABLE 11 HARVEST RECORDS, 1979-80 THROUGH 1983-84 FOR THREE REGIONS OF NOVA SCOTIA AND THE PROVINCE[1]

Year	Seven Western Counties[2]	Seven Eastern Counties[3]	Cape Breton	Provincial Total
1979-80	146,826	302,948	82,410	532,184
1980-81	88,789	158,543	76,004	323,336
1981-82	113,286	195,496	71,080	379,862
1982-83	186,542	276,524	84,500	547,566
1983-84	183,167	214,560	110,397	508,124
5 year totals	718,610	1,148,071	424,391	2,291,072[4]

[1] Small Game Harvest Trends. *N.S. Conservation* 9(2). Summer, 1985.
[2] Annapolis, Digby, Kings, Lunenburg, Queens, Shelburne, Yarmouth
[3] Antigonish, Colchester, Cumberland, Guysborough, Halifax, Hants, Pictou
[4] About 43 rabbits for every square kilometre (110 per square mile) including cities and towns.

as a sport animal than for food, but there are still areas (e.g., Northern Maine) where it is valued and readily used as a winter food item.

For many years the snowshoe hare was tinned and sold throughout Newfoundland. Those fishermen with available canning apparatus for salmon used the same types of tins for rabbits during winter (Dodds, 1960a). Rabbits were also eaten fresh and salted. Today in Newfoundland they are usually bottled (with a bit of pork) or eaten fresh, and they are still sold by the brace. Indeed, imported Nova Scotia hare have often been sold in towns along Newfoundland's west coast. In a province where fresh meat is not always available to some of its coastal people, the rabbit is an important complement to the diet. For some, it remains a staple.

Negative values

The creature we love to see on one side of our house may be quite unwelcome on the other side, if we have our garden there. In vegetable gardens and flowerbeds this cuddly animal suddenly becomes a pest, a genuine nuisance or even a "gosh darn rabbit" that causes the gardener to reach for the shotgun. I had just such a problem the summer of 1985 when, on any given morning, I could watch from one to five bunnies of varying size munching grass, clover and daisies with their queer crossways munch. It was great fun watching the daisy disappear! The trouble was that they cleaned my broccoli in a single night, pruned my peas and clipped everything else but tomatoes, squash and potatoes, including an occasional onion. Early in the summer we had kept the cat in until I had cleared the viewing area of rabbits by chasing them and clapping my hands, but later when the garden began to disappear, we let the cat out early in half-hopes the cat would catch one.

Snowshoe hare are damaging to gardens wherever gardens are placed adjacent to good rabbitat and whenever their populations are high. In agricultural areas hare may clip branches of apple trees from the row next to their cover and feed rather generously on commercial crops such as peas and beans. But although the gardener and farmer may have to take some protective measures, it is the forester who is most upset over hare feeding habits. Both plantations and natural regeneration may suffer when hare populations are high. Back in 1944 Aldous and Aldous called the snowshoe hare "a serious enemy of forest plantations" and concluded that:

1. "Though snowshoe hare have always fed more or less on coniferous seedlings, the effects were not forcibly brought to the attention of foresters until attempts were made to reforest unproductive areas by large-scale planting.
2. "Hare nip off the terminal and lateral buds and stems, thus tending to deform the trees as well as to retard their growth. This injury becomes apparent with each cyclic increase and is little noticed during the periods of relatively low population."

Hare were also recognized, 40 years ago, as animals that could influence forest succession (Cook and Robeson, 1945). These researchers noted "considerable selectivity in the choice of food" and that "white pine, red pine and white

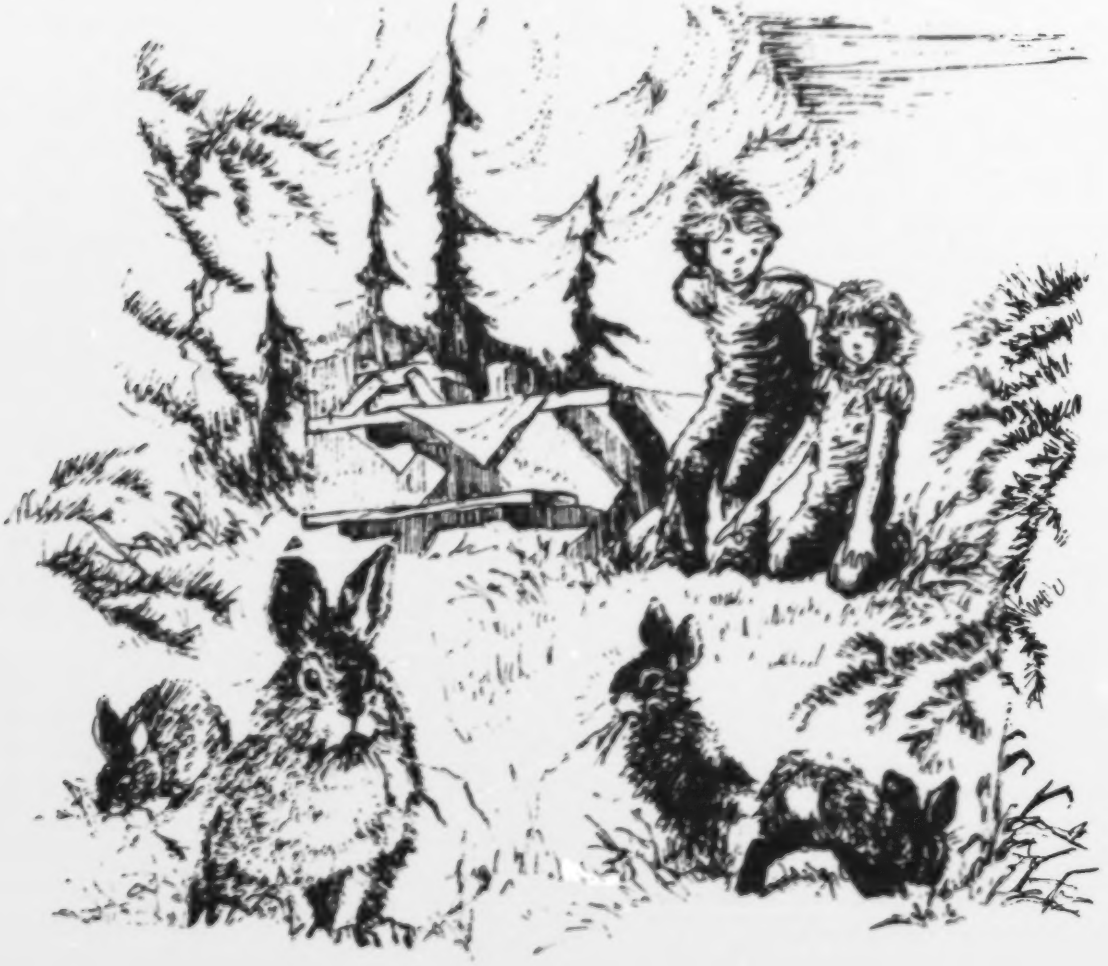
spruce seedlings less than four feet tall were killed outright; larger trees were trimmed as high as the hare could reach. Balsam fir and white cedar were not fed upon." They also prophesied that ". . . the snowshoe hare may yet become a problem in the Northeast (of U.S.A.)." Their study was conducted on Valcour Island in Lake Champlain.

If we look back to Chapter 2 on foods and feeding, we note that the Nova Scotia data indicate hare browsing heavily on white, red and black spruce and even balsam fir. They also indicate that the pines, especially white pine, are browsed here. And a glance at Appendix I shows that several species of pines as well as hemlock are used heavily in some areas. When high densities of rabbits are present and in good rabbitat one can expect feeding on smaller trees and seedlings of commercially important conifers in Nova Scotia. However, the overall detrimental effect on wildlings is not great.

Occasional damage can be expected with planted stock. Oxenham (1983) found browsing to be correlated well with plantation cover in central Nova Scotia. The proportion of plants browsed reached 60 percent where competition was "severe". Some reforested areas in Nova Scotia have had to be replanted partly as a result of browsing damage from hare and/or deer. When heavy browsing causes a need for replanting, costs are increased and time and effort wasted.

Hardwood regeneration may also suffer in some instances. An experimental program designed to increase regeneration of yellow birch in eastern Nova Scotia in the mid-sixties was ruined when rabbits moved into hardwood areas in the early spring and clipped the birch wildlings off just above ground level. Often deer are blamed for damage actually done by rabbits, and this was the case in the yellow birch study.

Thus, we find that although the positive benefits of rabbits ecologically, economically, recreationally and esthetically are great, local negative impacts from high density populations must be recognized and dealt with. Of course, the left hind foot of a rabbit is lucky!



Management of Snowshoe Hare

When we speak of management, we are considering any purposeful human intervention affecting hare numbers or their habitat. Sometimes this involves controlling people, such as in regulatory management where people may be restricted in the times of the year they can pursue their quarry. Sometimes it is a "positive" measure to enhance rabbit numbers such as habitat improvement. Sometimes it is a "negative" measure (viewed from a rabbit's standpoint) such as a control to prevent depredation by rabbits. Management, then, covers a wide variety of activities and policies which bear on human behaviour, public attitudes, rabbit populations and rabbit values, both positive and negative.

Regulatory management

In Chapters 4 and 5 we indicated the numbers of snowshoe hare that might exist at high and low densities as well as the number that could be eaten by a population of predators. Then, in the preceding chapter, we noted that a half a million hare are harvested each year by people in Nova Scotia. Well, now, just how many rabbits are out there anyway? This question is meaningful if we recognize a need for regulations or even if we feel the rabbit needs no protection at all. For instance, how does a manager "know" when to suggest bag limits, where normally there have been none? When does combined mortality actually reduce the breeding populations of rabbits?

Just for fun, let's look at some guesses about rabbits in Nova Scotia to get a feel for what we are dealing with. We'll take the low figure of 74 per square kilometre (192 per square mile) quoted from Keith and Windberg (1978) in Chapter 4 and multiply it by 46,600 as an approximate area, in square kilometres, inhabited by hare in Nova Scotia (18,000 square miles). This gives us approximately 3.5 million animals. If we had 5,000 wildcats, each of which consumed 200 rabbits a year, one million rabbits would be removed. Take another half million away for human harvests and another million for other mortality, including accidents, diseases and other predation from coyotes, owls, dogs, foxes, house cats, and lynx, etc. We would be left with about one million hare, of which half would be females that would each produce an average of 7.5 young or 500,000 x 7.5 = 3.75 million (just about what we started with). Maybe we would really lose more to disease or predation or something else. Nevertheless, we are clearly dealing with a massive amount of energy flowing through our systems.

Of course, these numbers are only an exercise in what might be happening. The various types of predation including human harvests are additive, in part. That is, a portion of the human harvests are added to all other losses rather than compensating for one or more of them, at least when rabbits are plentiful. Do rabbits then need protection? Regardless of our imaginary numbers that suggest they don't, they do need some protection, and this comes from regulatory management (of people).

Regulations may operate in various ways: limiting the number of animals harvested in a given period (bag limits), limiting the length of seasons, determining the sex that can be killed, setting the time of day animals may be taken, determining the method of killing and the areas in which animals can be harvested, preventing the use of specific aids (e.g., lights) — or any number of other measures. In some jurisdictions where

the range areas are limited and/or where hunting pressure is very great, daily bag limits are adopted for snowshoe hare and even season limits may be imposed. Of course, it's not possible to tell the sex of a rabbit without a close "in hand" examination, so both sexes are harvested.

Seasons in the southern parts of the species' range tend to be rather short — from late fall to mid-winter. Seasons in the more northern areas are longer. In many areas of its range, the hare can only be hunted (shot, usually with a shotgun), but snares are used in much of its northern range as well.

Our rabbit hunting season is a conservative one. It opens after most of the juveniles have reached full growth, and even those produced as late as mid-August should weigh one kilogram or more. By the first week in December hunting begins in earnest in Nova Scotia, when there should only be a very few smaller animals left around. Little hunting of rabbits is carried out here until the deer season closes. The rabbit season closes in mid-February. This is several weeks before breeding begins although pre-copulatory chasing may have started, but courtship behaviour remains undisturbed by harassment from hunting.

During the deer season snowshoe hare can be hunted with shotgun only, but after the deer season closes a .22 calibre rifle may be used. This restriction is to help prevent deer being wounded by the over-eager rabbit hunter. The .22 calibre rifle is not a legal weapon for deer hunting.

There is no bag limit in Nova Scotia, and so far the rabbits have done quite well. If for any reason our rabbitat declines drastically in future years, or if additional major mortality factors enter the picture (disease, coyotes possibly), it would be wise to undertake a detailed study of productivity and mortality to determine the need for more restrictive limits or seasons. At present, further restrictions are not required.

There are two practices with which portions of the Nova Scotia public are sometimes unhappy: one is the use of snares, and the second is the sale of the animals. As an efficient means of harvesting hare, the properly set snare is both effective and deadly. The first neck vertebra of a rabbit disarticulates with ease from the back of the head. Any person who has killed lagomorphs in the hand knows that a sharp blow with the side of the hand at this juncture will kill the animal quickly. In a snare this "break" often occurs. If it doesn't, lagomorphs are among the quickest to die by strangulation as the muscles around the trachea (windpipe) are poorly developed. Since many snares can be carried and set in a short time, it is an ideal harvesting technique for commercial operations or for any "meat-hunter", young or old.

The sale of rabbits, while repugnant to many, is of considerable importance to some families in Nova Scotia who look to these animals for a part of their livelihood. Rabbit catching and rabbit sales are traditional in many rural sections of the province, and since, as of this time, neither the snaring of rabbits nor the sale of them appears to be detrimental to populations, both are acceptable from a management viewpoint. Of course problems may be present in some local areas if snaring is particularly heavy.

Rabbitat management

If you want more snowshoe hare on your land you will have to provide the low escape cover and the food plants favoured. If your land borders habitat already inhabited by rabbits then you will have no problem. You will have lots of bunnies, but as we have noted before, there will sometimes be only a few, since their fluctuations in numbers will occur on your land whether you hunt them or not. Of course, if you only have a backyard and no land to work with you'll have to be content with the occasional backyard hare that may appear in your neighbourhood. For land holders with medium to large size holdings, natural succession following cutting will provide food and cover for hare for several years until the canopy prevents light from hitting the forest floor, resulting in a dearth of low vegetation. Normally, you will be managing for trees rather than rabbits, but in doing so, you will provide good rabbitat for several years out of each rotation period. There may be some areas, however, such as alder beds or a mixture of heath plants at a bog edge, which will "always" be present. Preventing the destruction of these areas will allow a few rabbits to be present regularly.

Damage prevention and control

One obvious way to prevent damage to gardens and crops is to plant in cleared agricultural areas where there are no snowshoe hare. Unfortunately we are restricted to planting on land to which we have access, which may well be in the middle of, or adjacent to, wooded areas inhabited by rabbits. In such instances, the only really effective method of controlling depredation in gardens is to prevent access by rabbits to the vegetables. The easiest way to do this is to fence with fine mesh "hardware cloth" wire or chicken wire, making sure the bottom of the fence is on the ground in all places. To be certain rabbits don't jump over the fence, a height of about 75 cm (30 inches) is suggested, with the fence tilted outward at the top.

There are all manner of repellents marketed, but none has proven to be effective beyond short periods, so re-application is required regularly. Several repellents have a fungicide base (such as thiram) and some "home" remedies use creoline or moth balls. There are also scare devices which may be effective for a "one-shot" try, but during the reproductive season, rabbits feed for many hours each day and they are not easily dissuaded. They will soon get used to the alarm notes or explosions — if indeed the alarms frightened them at all.

Usually noise alone will not frighten snowshoe hare.

Other techniques are the use of silhouettes (of raptors), flags or pieces of moving plastic or pinwheels, all set low to the ground. But none is really effective; so fence the garden!

In the case of fruit trees or ornamentals, the best damage prevention approach is to use fine wire mesh cylinders around the plants to a height that will prevent hare damage in winter as well as when snow is not present. Any commercial tree wrap, used to prevent rodent damage, can also be used on fruit trees, but on many ornamentals it is often difficult to wrap the vulnerable areas.

Forest plantations provide the greatest control challenge. This is a subject that has been "researched" for many years. In 1944 Aldous and Aldous concluded that "the success of many plantings depends on the protection afforded the seedlings during the time of population peaks . . ." and that ". . . no highly effective methods can be recommended for protecting the young seedlings from damage. . . . " More than 40 years later we are still in the same position, examining cultural and chemical control approaches to protection. Gillis (1976) reviewed the browsing control literature for the Nova Scotia Department of Lands and Forests and concluded that at that time the literature did not offer ". . . an easy solution for controlling browsing of softwood seedlings by rabbits. . . ." The 10 years since the Gillis review have not provided much that is new. There are, however, certain observations and logical approaches that can help:

1. Nursery stock may be browsed more readily than wildlings. Presumably nutrient uptake from applied fertilizers in the nursery provides a more palatable and nutritious plant for rabbits (and deer).
2. The greatest damage occurs in late fall and early spring or at times during the winter when snow cover may be scant or absent.
3. Browsing tends to increase with the presence of competitive cover such as raspberry, red maple and pin cherry.
4. Browsing damage is usually greatest within 45 m (50 yards) of snowshoe hare cover, but in late winter and early spring, when rabbit movement is greatest, considerable damage may occur at greater distances.
5. Browsing damage is greatest during periods of high density rabbit populations.
6. Pines (*Pinus* spp.) are selected over spruce (*Picea* spp.), but if rabbit populations are high and food is scarce, selectivity is less apparent and all seedlings may suffer.
7. Ordinarily, most rabbit damage is restricted to lateral shoot browsing. But terminals may be taken, especially on small seedlings a few centimetres out of the snow.

Approaches to reduce damage:

1. Since damage is likely to be positively correlated with available cover it would serve forest management purposes best to eliminate irregular edges of cutovers as well as all "islands" of cover left because the wood was unmerchantable. A cutover with an even edge and no cover areas left in it would be far less vulnerable than most customary cutovers. In fact, these often present a near ideal edge situation allowing hare easy access to the highly nutritious planted stock. These "peninsulas" and "islands" of cover could be cut or, even better in most instances, bulldozed.

2. Any pre-planting treatment that provides cover (for example windrows) or is likely to provide competitive cover during the first two years following planting should be avoided, if possible.
3. If the hare density index (from pellet counts, track counts, browse indices or kill data) is particularly high and planting can be postponed, delay planting for one or, if necessary, two years. If planting "must" take place, use vigorous stock only.
4. Plant pines farther from edge cover than spruce.
5. Although probably not very effective in late winter or where competitive cover is dense in the planting area, a buffer zone of 20-30 m (bulldozed bare) around all edges should reduce damage except when hare densities are high. Of course, the loss of planting space must be measured against projected losses from rabbits. Still another approach would be to reduce adjacent vegetation temporarily (for two years) with herbicides.
6. The best cold weather repellents can be selectively applied during late fall and again in late winter-early spring, probably to some advantage.
7. Hare numbers can be reduced locally by effective snaring and less so by hunting. Encouraging both in areas where damage is expected to occur certainly won't hurt.
8. The provision of alternate food sounds like a reasonable approach, but since damage appears to increase with competitive cover, which often provides alternate foods, and since rabbits appear to be attracted to freshly cleaned softwood areas the first fall-winter following cleaning, the alternate food must be provided outside the planting. The "chop and lop" system of dropping hardwoods and leaving the cambium intact on the drop side will provide rabbits with tops to feed on and, if located a short distance inside their cover units, should be helpful in reducing damage in the more open plantings. Favoured species (birches, aspen and maples especially) should be selected.

It may be that more effective chemical repellents will be developed. However, it seems likely that the "predictive" approach (Gaul, 1983) holds some promise. This involves assessment of rabbit populations, planting sites and adjacent habitats to tell the forester the chances and degree of depredation that may occur. After a browsing hazard potential is established, damage can be lessened by delayed planting, more intensive protection and control, or by altering adjacent habitat.

Regardless of control measures taken, hunters and naturalists should not fear for the snowshoe hare. Even if all adjacent cover areas next to new plantings were "knocked down" for two or three years, this would only be a minuscule part of rabbitat in the province and would probably have little effect at all on overall populations.

Hunting the snowshoe hare

It's not the hare that is being managed when we talk about hunting so much as it is the people who hunt. Of course, the kill returns and other data that may be collected from hunters help the biologists to monitor hare populations. But if neither hunting nor snaring took place, hare populations would still increase and decrease, with hare probably not being much more of a problem as depredators than they are now — at least in Nova Scotia.

But hunting may indirectly help to stimulate productivity by regularly removing a proportion of the population each year. This helps keep our rabbits from browsing their food supplies to levels that would reduce the carrying capacity for more rabbits. While hunting is not necessary in order to have rabbits, it may help guarantee that the range will continue to support rabbits. Hunting and predation help hold the numbers down throughout a fluctuation. Doubtless starvation and disease would effect reductions if hunting and predation did not; this occurs in our parks and sanctuaries. In this sense hunting and predation are probably compensatory in relation to starvation and disease.

As noted in Chapter 7, rabbit hunting in Nova Scotia is conducted both with dogs and without dogs. Most hunters prefer to hunt when light snow covers the ground. Snow conditions are very important to the success of the hunt, and surface tension is one of the most important snow characteristics. Dogs will sink where rabbits don't! Although the dogs used for upland game birds (setters, shorthairs, springers, etc.) are perhaps more glamorous, and the joy obtained from watching such dogs work may be great, the lowly beagle is not to be sneezed at. Beagles are compact little units with lovely voices, and most beagles have singularly one-track minds. They "live" to follow the scent of rabbits, scurrying along the trail with nose to the ground, tail wagging and giving forth an occasional howl that rabbit hunters consider highly musical. Since rabbits normally stay within their home range (Chapter 5), waiting on the woods road for the quarry to cross at one of the many crossing points (many in good rabbitat) is an enjoyable way for the rabbit hunter to spend a sunny winter afternoon. Meanwhile, the dog pushes the rabbit ahead of it; and when the beagle is reasonably close, watch carefully! Sometimes several hunters will enjoy a day out after rabbits, and usually, one beagle is sufficient or even better than two beagles. Still, two are often used.

Other hunters prefer walking without dogs, searching out the "resting" hare or "jumping" them from low cover. In relatively open cover, when snow is on the ground, the careful hunter can find his "resting" hare and kill it quickly with a .22 calibre rifle (after the deer season). In this case a low power scope helps. In thicker cover a hunter may use the shotgun more often since the running hare is not a good target for the .22 except for a few very skilled people. Shotguns of 20 and 16 gauge are most often used, but some gamble with a .410 or make certain they don't gamble with a 12 gauge. Number six shot shells are used most often by 16- and 12- gauge enthusiasts and number four or six for .410- and 20- gauge people.

Hunters should always seek permission from landowners before going onto property other than Crown land. Sometimes the owner might enjoy receiving a hare for the pot too — skinned and dressed, of course.

Snaring the snowshoe hare

The properly set snare is highly effective in taking hare. Young people and commercial rabbit catchers are the two most important groups that set them. For the boy or girl, setting the rabbit snare is often one of the earliest wildlife experiences in which an animal is killed. It is important that these first experiences are humane, efficient and positive. Poorly set snares can indeed cause the animal to suffer, and there is little excuse for this.

The key to making certain the animal will not suffer is to ensure that the snare opening is a proper size. This will prevent the rabbit from getting a foot through the hole. If only the head enters, the animal will die quickly. If a foot or both front feet get through, the animal will suffer, and much muscle tissue will be bruised making the rabbit partially unfit to eat. A second precaution is to make certain the rabbit will not run off with the stick to which the snare is attached, causing it undue stress. Never tie a snare to a solid stake or tree where the wire may break on the first jerk. Use 20-gauge rabbit wire, since anything smaller will often break. Lastly, always make certain the snare is set the proper distance from the ground or snow trail, because this determines success or failure.

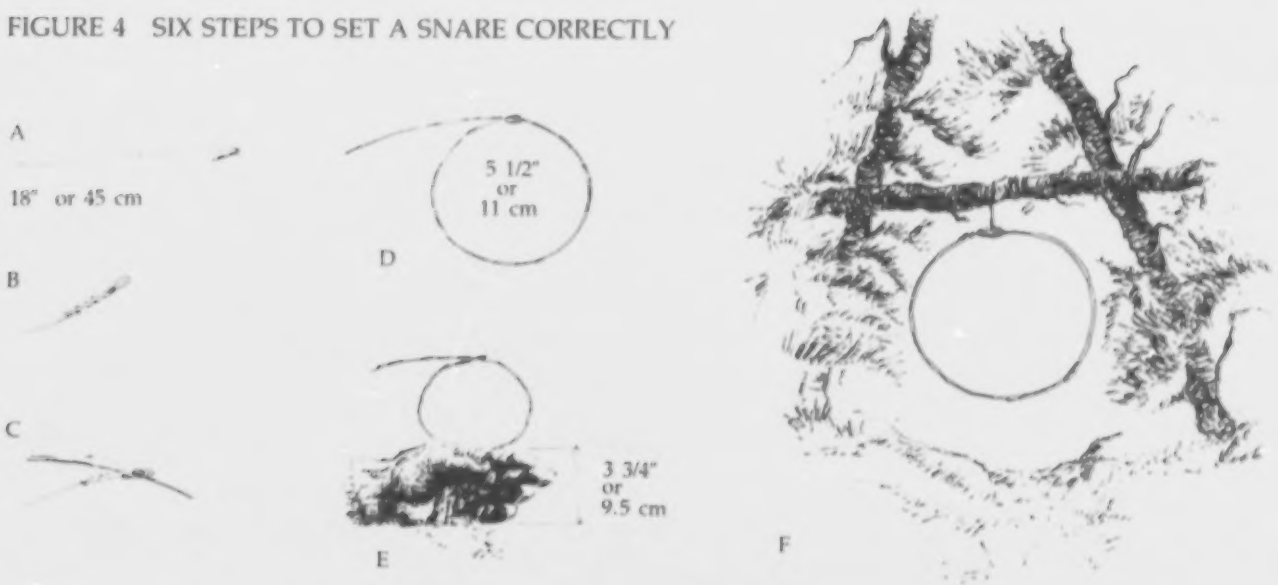
Snares are set along the rabbits' trails or in openings of "hedges" made by the rabbit catcher. A hedge is made from brush and small trees cut and placed in a line, semi-circle or other shape. Sometimes trees alone are dropped and snares set between or within the horizontal branches. Often it is necessary to block off the sides or approach on a path or opening to make certain the animal is guided into the snare.

Tending snares daily is important to make certain that an improperly caught rabbit can be attended to and to prevent your rabbits from being eaten by predators. In Newfoundland, I often lost rabbits to lynx. Over a three-year period I actually had hundreds of animals taken or left partly eaten. Bobcats and even coyotes may take hare from snares. Foxes will not, unless there are exceptional circumstances. Domestic dogs or feral cats will also take your catch or eat parts of it. Weasels will often eat the soft tissue, breaking into the body cavity and feasting on the testes or ovaries, kidneys and liver. Sometimes weasels will eat about the head, taking the eyes and feeding about the lips and cheeks or eating heart and lungs. Nearby owls

may take the hare when it is caught but still alive. Jays, particularly grey (Canada) jays, will peck dead rabbits too. I've seen snared rabbits completely destroyed from early morning Canada jay pecking.

It is also necessary to make certain *all* of your snares are taken up when you finish snaring. Don't ever leave snares in the woods. I have retrieved hundreds of other peoples' rabbit snares after the season and, unfortunately, almost as many fox and wildcat snares. The snare left is still deadly, and it can catch and kill whether the season is open or not. Too many people are just plain lazy or thoughtless. They set snares and check them until a heavy snowfall covers them. After that they "forget". After all, snare wire is cheap!

FIGURE 4 SIX STEPS TO SET A SNARE CORRECTLY



The snowshoe hare in captivity

Snowshoe hare can be raised in captivity, but it is necessary to watch carefully for evidence of poor condition and disease. Even with good care and veterinary treatment hare may perish. Hare succumb to stress readily, and since their metabolisms are rapid, they will deteriorate quickly when bacterial or viral infections occur producing negative energy balances. Still it is possible to raise them, under permit of course. The following notes from Dodds (1960a) provide information on holding, feeding and live-trapping the animals.

"Hare were raised under captive conditions on wire, in pens raised 16 inches from ground level. Half-inch-mesh welded wire formed the bottom of the pens but quantities of hay were provided to prevent all pellets from dropping through to the ground (re coprophagy) and to provide bedding. Pens were constructed in four units measuring 3 1/2 feet wide, six feet long and 18 inches deep. A foot-wide runway extended lengthways between each pair of units and sliding doors leading to the runway were arranged in each unit. Overall dimensions for a four-unit pen were 13 x 8 x 1 1/2 feet. Covers of felt roofing paper were placed over three feet of either end of the entire unit, extending around ends and sides so that each unit was half covered. Light gauge chain-link wire was used on the sides and top. Wires leading from the top of sliding doors in each unit extended through the covered section so that doors could be raised at will.

"Balanced ration Purina rabbit pellets were fed throughout the year. Dishes were kept full at all times. Birch twigs were fed during the winter, although cherry, spruce, mountain maple, raspberry, alder and balsam fir were also used. Birch was preferred at all times when other species were provided (sugar maple, red maple, aspen and striped maple were not available). Water was provided beginning in May and extending until the first snow (usually November). During the winter, snow was provided and used considerably by the hares. Water consumption was very low in the spring (May and June) after greens were first introduced. Greens were made available until early fall but consumption appeared to decrease beginning in August. Clover was preferred among a long list of greens provided. Water consumption was highest (about one-half pint per day) in mid-summer.

"Live trapping was conducted with the aid of traps especially constructed for lightness as they often had to be carried considerable distances on foot. Traps measured 36 inches long by 13 1/2 inches wide by 13 1/2 inches high. Framing was constructed of 1 1/2 inch lumber and covered in half-inch mesh welded wire. Doors hinged at the bottom and folded in with a straight length of heavy telephone wire catching on the under edge of a treadle at the bottom of the trap. Doors were constructed of chicken wire attached to a frame of the telephone wire and measured 13 inches by 13 inches. The springs operating the doors were taken from rat traps.

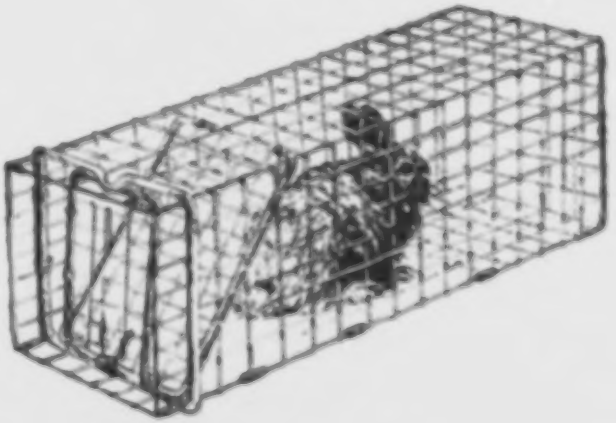
"To prevent icing and snow clogging, traps were often covered with fir or spruce boughs. Fresh birch twigs were placed at the entrances to attract animals but good results were obtained simply by placing traps on well used paths when snow was fairly deep."

Today the cost of rations would put overall expenses rather high, but if sufficient greens and woody browse were available to use with the commercial feed, after the rabbits reached about one kilogram (two pounds), raising them might be feasible. Mortality would also have to be prevented or kept very low.

Monitoring for management

Although rabbits, with their propensity for breeding, sort of take care of themselves, they are vulnerable to disease which can decimate their numbers on occasion. In addition, they will over the next several years gradually lose portions of their range in Nova Scotia as development, clearing for agriculture and more intensive forest management take an increasing proportion of the land base from their supply of good habitat. Hunter numbers, too, are increasing in Nova Scotia and are likely to increase for several years. For these reasons and because of the fact that predators depend on rabbits, the monitoring of their numbers is important. In addition, their numbers need to be monitored in light of their damage to forest plantations and to provide information for the user public. Thus, there is the need for management and for data to provide the information base to keep track of rabbit populations.

Monitoring of populations is accomplished in Nova Scotia by gathering the harvest data indicated on small game license returns. In addition, there are subjective observational data from staff and from sportsmen. Although these extensive approaches fail to pick up minor population changes, it is possible to detect major changes between years, and trends over a period of years. Intensive population studies in areas where movement in and out of the area can be monitored are always important. When it becomes necessary to have more precise data, biologists can use radio tracking, toe clipping, pellet and track counts, live trapping, tag-and-release or other techniques in study areas. Crosschecks on these data can be made from pellet count indices and the extensive approaches already mentioned. Another extensive data crosscheck can be obtained by comparing browse data from annually sampled plots or lines. Analyses of hunter success and snaring success in relation to effort may also be employed, as well as "controlled" roadside counts in early summer. Whatever approaches are used, it is important to keep on top of what is happening to hare populations. It is also important to pass this information on to the publics who comprise the client base for wildlife managers.



The attitudes of people toward wildlife vary depending upon many factors, including the rural-urban factor, education, religion and economic levels, to name a few. But although attitudes are a reflection of these and other things, attitudes in general are changing. Urbanization and the strong influence of special interest groups, through our modern media and the overall movement of humans away from a "hands on" dependence on the land, have spawned populations of people who relate to animals far differently than did their parents and grandparents.

Attitudes

Probably the most important assessment of societal groups that can be considered a reasonably close reflection of how Canadians and Maritimers think is the long-term study of Stephen Kellert of the School of Forestry and Environmental Studies at Yale. The following classification (Figure 3) indicates the wildlife attitudes exemplified by his sample (Kellert, 1980). These attitudes are listed again in Table 12 along with estimated percentages of Americans strongly oriented toward each one. By studying the table and adding percentages, one can see that the sum of the humanistic and moralistic estimates (55) is more than one third of the total (148). If a portion of the naturalistic, ecologistic and esthetic are added, then it is likely that half or more of the American population do not approve of hunting. Many are also negative toward management since population reduction and/or harvesting can be included in management.

Without more intensive management of *all* our resources we are not likely to do too well in the future however. Because more intensive agriculture, forestry and overall land use management is going to occur, our wildlife populations, including our snowshoe hare, also require greater management attention. This management may mean protection of the animal or it may mean protection of crops and the removal of the animal.

Wild meat is good meat for human consumption. It has no additives and, in most cases, will be free of chemicals applied in other resource management by man. If there is a difference, wild meat should be a "healthier" product than "domestic" meat. The use of wild animals is also consistent with Christian thought and both the Bible and the Book of Mormon attest to this. Today, outdoor experiences gained in the pursuit of wild animals are both recreationally sound and, to millions, therapeutic. Data obtained from animal harvests provide a reasonable means of monitoring the health and status of populations. In addition, the use of wild animals is economically and socially beneficial to millions. Indeed, we still have people among us on this earth who could not live without killing and using wild things.

In Nova Scotia, peoples' attitudes probably cover the spectrum Kellert has described. Commercial rabbit catchers are obviously on a different wavelength from those involved in the humane and animal rights movements, yet both want the species and populations to survive. At these levels we are one. We differ in the use of the rabbits and how we are to ensure the rabbits' continued existence. It is important for those involved in managing rabbits and all wild animal resources to have as thorough an understanding as possible of the many attitudes expressed by their

clients — the users of the resource. The managers must provide as many of the attitude groups as possible with something positive, whether it be an area where snowshoe hare are completely protected (such as zoned areas), or, conversely, guarantees of access to designated Crown lands for those who would harvest them.

FIGURE 5 WILDLIFE ATTITUDE GROUPS IN AMERICAN SOCIETY

Naturalistic
Primary interest and affection for wildlife and the outdoors.

Ecologistic
Primary concern for the environment as a system, for interrelationships between wildlife species and natural habitats.

Humanistic
Primary interest and strong affection for individual animals, principally pets. Regarding wildlife, focus is on large, attractive animals with strong anthropomorphic associations.

Moralistic
Primary concern for the right and wrong treatment of animals, with strong opposition to exploitation of and cruelty toward animals.

Scientistic
Primary interest in the physical attributes and biological functioning of animals.

Aesthetic
Primary interest in the artistic and symbolic characteristics of animals.

Utilitarian
Primary concern for the practical and material value of animals.

Dominionistic
Primary satisfactions derived from mastery and control over animals, typically in sporting situations.

Negativistic
Primary orientation an active avoidance of animals due to fear or dislike.

Neutralistic
Primary orientation a passive avoidance of animals due to indifference.

TABLE 12 ATTITUDE OCCURRENCE IN AMERICAN SOCIETY

Attitude	Estimated % of American Population Strongly Oriented Towards the Attitude[1]	Common Behavioural Expressions	Most Related Values/Benefits
Naturalistic	10%	outdoor wildlife related recreation, backcountry use, nature birding and nature hunting	outdoor recreation
Ecologistic	7%	conservation support, activism and membership, ecological study	ecological
Humanistic	35%	pets, wildlife tourism, casual zoo visitation	companionship, affection
Moralistic	20%	animal welfare support/ membership, kindness to animals	ethical existence
Scientistic	1%	scientific study/hobbies, collecting	scientific
Aesthetic	15%	nature appreciation, art, wildlife tourism	aesthetic
Utilitarian	20%	consumption of furs, raising meat, bounties, meat hunting	consumptive, utilitarian
Dominionistic	3%	animal spectator sports, trophy hunting	sporting
Negativistic	2%	cruelty, overt fear behaviour	little or negative
Neutralistic	35%	avoidance of animal behaviour	little or negative

[1]Totals more than 100%, as persons can be strongly oriented toward more than one attitude.
From: Kellert (1980) *in* Shaw and Zube (1980).

What will happen in the future?

With increased intensive land use in our resource-based industries and with a need to respond to a wide variety of client attitudes, the management of snowshoe hare will certainly become more intensive. Whether the changes will be toward the zoning of our hare range to provide non-snaring areas first or whether they will be of a more specific regulatory nature concerning something like bag limits in certain areas, we don't know and shouldn't try to predict. Perhaps the only clear "management approach prediction" we can make with some degree of certainty is that our forest and agricultural interests will most surely be better protected, not only from snowshoe hare but also from porcupine and deer. This protection may be cultural, of course, but it may also involve the removal of the depredators.

Hunters and non-hunters alike will be better informed in future years, particularly if information and educational efforts are strengthened. You all have a stake in our rabbits. Make certain you are well informed. Join an interested wildlife group, encourage research and management and contribute from a sound background of knowledge and understanding.

Hasenpfeffer

As van Nostrand (1971) noted in *Snowshoe Hare in Nova Scotia*, Nova Scotians probably eat more rabbits than they do any other game. If possible, it's a good idea to skin and dress rabbits in the field or, at least, soon after they are shot or snared. Hunters often carry a few clean plastic bags with them to hold the cleaned rabbit, and since the head and feet will be removed, it takes up very little room this way in the pack or in the back of a hunting jacket. If you don't have plastic bags with you then leave the skins on your rabbits until you get home, since you don't want the flesh to dry out and you don't want the inside of your jacket soiled.

Rabbits can be frozen in air-tight bags either whole or cut in pieces. They may also be bottled (canned) with a bit of salt pork in each jar and, if you have a "pickle" barrel or salt pickle container, rabbits can be salted.

Before cooking the fresh or fresh-frozen rabbit all fur, visible lead shot and blood should be removed. Some people also soak the rabbit for a short time in salt water, but it is really sufficient to wash the meat clean. Rabbit meat is bland, and although all rabbit meat should be tender, fried rabbit or other "fast-food" preparations may prove a bit stringy if the rabbit is an old one. We know that we are unlikely to have many "old" ones however, since most rabbits taken will be the young of the year. Rabbit meat is also almost completely devoid of fat. It is good for you. Just don't overdo the seasoning since it is easy with bland and fat-free meat to drown the real taste.

The following recipes are only a few of dozens that are available for preparing hare or rabbit. The first seven are from Charles Cadieux, *Wildlife Management on Your Land* and the remaining three are from Neil van Nostrand's *Snowshoe Hare in Nova Scotia*. Specific references used by van Nostrand, as well as the reference for the first seven, are listed following the recipes.

Fried Rabbit

2 dressed rabbits in serving-size pieces
1 1/2 cups flour
1 tsp. salt
1/2 tsp. pepper
3 tbsp. salad oil
2 tbsp. butter
2 chicken bouillon cubes
1 cup hot water

Dredge rabbit pieces in flour, salt and pepper until well coated. Brown on all sides in a mixture of the salad oil and butter in a skillet. Dissolve bouillon in the hot water and pour over the meat. Cover and cook for 45 minutes over low heat, or until fork- tender.

Hassenpfeffer

1 dressed rabbit
1 cup cider vinegar
1 1/2 cups water
2 tsp. salt
1/4 tsp. pepper
1 tsp. whole cloves
2 tsp. sugar
6 bay leaves
1 cup sliced onion
6 tbsp. flour
oil for frying

Place rabbit in enamel or glass bowl. Mix vinegar, water, salt, pepper, cloves, sugar, bay leaves, and onions, and pour over rabbit. Cover and let stand in refrigerator overnight. Remove rabbit and pat dry with paper towel. Dredge in flour and fry in 1/8-inch hot fat. Add the marinade in which the rabbit spent the night, cover tightly, and simmer for 1 hour or until rabbit is tender.

Rabbit Pie

1 rabbit, cut into serving pieces
vinegar
water
salt
pepper
flour
2 onions, sliced
2 carrots, diced
3 potatoes, diced
flour
rich biscuit dough

Marinate rabbit overnight in equal parts of vinegar and water. Dry. Sprinkle with salt and pepper and dredge in flour. Sear quickly in frying pan, add water to cover, and simmer slowly for 1 1/2 hours in covered pot. Add vegetables, and cook until they are done. Thicken stew with flour. Put in greased baking dish and cover with rich biscuit dough crust. Return to oven and bake at 400°F until crust is done.

Rabbit Sesame

1 rabbit, cut into serving pieces
1 egg, beaten
salt
pepper
1 tsp. seasoning salt
1/4 cup sesame seeds
1/4 cup cooking oil
1/4 cup butter
3/4 cup chopped celery
1 onion, sliced
1 bell pepper, chopped
1 small can mushroom bits and pieces
1 tbsp. Worcestershire sauce
16-ounce can stewed tomatoes
1/2 cup cold water

Dip rabbit pieces in beaten egg, then into a bowl with the salt, pepper, seasoning salt, and sesame seeds. Then pop the rabbit pieces into a hot skillet, with the cooking oil, for 20 minutes over medium flame. Remove the rabbit. Add butter to oil and sauté celery, onions, and green bell pepper until tender. Put the rabbit back in, and add the tomatoes and mushrooms with their juices. Add water and Worcestershire sauce. Cover and cook until rabbit is tender. Serve over buttered noodles with Parmesan cheese sprinkled on top.

Rabbit in Cream

2 rabbits, cut up
3 tbsp. flour
1 tsp. salt
dash black pepper
1/4 cup salad oil
1/2 cup milk
1 cup sour cream
1 cup sliced onions
1 minced garlic clove
1 tsp. salt
1 tbsp. flour
2 tbsp. cold water

Preheat oven to 350°F. Roll rabbit in 3 tbsp. flour combined with salt and pepper. Brown in hot oil in Dutch oven, add milk, sour cream, onions, garlic, and salt. Bake covered until tender (about 75 minutes). Arrange on hot platter. Blend 1 tbsp. flour with cold water, and stir this into sauce. Cook until thickened, then pour over rabbit.

Rabbit Stuffing

1 medium-sized onion, minced
1/4 cup chopped celery
2 tbsp. chopped green pepper
4 tbsp. butter
1 cup grated soft bread crumbs
1 tsp. salt
1/4 tsp. paprika
1/4 tsp. sage
1/4 tsp. poultry seasoning
1 carrot, grated

Cook onion, celery and green pepper in the butter until softened but not brown; remove from heat and add bread crumbs, seasoning and grated carrot, stirring until well mixed; add more butter if mixture is dry. Yields approximately 2 cups.

Rabbit Pot Roast
from *Outdoor Life*

Cut 2 rabbits into small portions, and, if preferred, soak overnight. Flour these pieces and brown them in bacon fat or melted butter. Place browned pieces in an iron pot, and add a quart of water, 1/4 cup of cider vinegar, a piece of bay leaf, and a slice of onion. Salt this mixture, and then add a heaping tablespoonful of butter.

Simmer very slowly until the meat literally falls from the little bones or can be poked off with a fork. Pick out all the bones, leaving the bits of meat in the pot.

About a half hour before serving, stir in a little milk and flour to thicken the liquid. Simmer until gravy is well mixed.

Serve over hot baking-powder biscuits (split and buttered). May also be served over rice or mashed potatoes.

Rappie Pie (Rabbit)
from *La Cuisine Acadienne d'aujourd'hui*

about 3 rabbits (5 or 6 lbs. of meat)
2/3 pail of potatoes
2 medium onions
salt and pepper

Cut rabbits into pieces, cover with water and cook. Add finely chopped onions, salt and pepper. Peel, wash and grate potatoes, noting how much you have in your pan. Squeeze potatoes (in a cloth bag, about 2 cups at a time) until quite dry. Pack in a bowl. When potatoes are all squeezed, loosen potato pulp in a large pan. Add boiling broth from the rabbits, gradually, and stirring slowly. If there is not enough broth, add boiling water until you have as much potato mixture as before they were squeezed. Salt and pepper to taste.

Grease 17" x 12" pan. Spread in half the potato mixture. Distribute rabbit pieces evenly over this, then cover with other half of potato mixture. Bake at 400°F for two hours. Should be brown and crusty on the surface.

Note: Since rabbit is not very fat, you may melt a piece of pork fat and add to the potato mixture.

Barbecued Rabbit

Dust pieces with flour and seasoning salt, then brown in cooking oil. Pour your barbecue sauce over the rabbit and cook for an hour at low heat. Goes great with beer. If you haven't got a favourite barbecue sauce, try this one:

3 tbsp. meat stock
3 tbsp. chili sauce
1 tbsp. Worcestershire sauce
1/2 cup ketchup
2 tbsp. vinegar
1 1/4 tsp. salt
1/4 tsp. black pepper
1 small onion, minced finely
2 tbsp. brown sugar
1 tsp. monosodium glutamate (Accent)

Stir together all ingredients and pour over browned meat. Baste occasionally if all of the meat is not covered by the barbecue sauce.

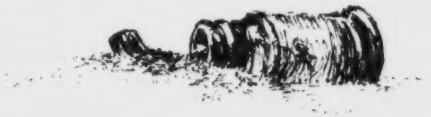
Rabbit Casserole

2 rabbits, cut up
flour
salt
pepper
1/2 cup cooking oil
1 pinch rosemary leaves
1 clove garlic, pressed
1/2 cup white wine
1/2 cup meat broth
1 tbsp. wine vinegar

Dredge rabbit in flour, salt, and pepper. Put oil, rosemary, and garlic in skillet and brown the meat in the mixture. Remove rabbit to a glass casserole. Add wine, broth, and vinegar to skillet, and bring the mixture to a boil. Scrape the pan thoroughly and pour it all over the rabbit. Cover and bake at 350°F until meat is tender. The juice makes good gravy, so serve it over pasta if you like.

Roast Stuffed Rabbit
from *Canadian Wild Game Cookbook*

Dress, clean, wash and dry rabbit; rub inside with salt, fill with stuffing (See Rabbit Stuffing), sew up, brush generously with butter. Sprinkle with salt and pepper and place on side in roast pan; roast, uncovered, in slow oven 325° to 350° F. for 1 1/2 to 2 hours, or until tender, basting every 15 minutes with melted butter and turning rabbit when half done. Serve with hot pan gravy.



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APPENDIX I.
FALL AND WINTER SNOWSHOE HARE FOOD ITEMS FROM VARIOUS NORTH AMERICAN STUDIES

Area	**Species Used** (Common name)
Alberta (Keith, Cary, Rongstad and Brittingham, 1984)	Willow Alder (common or speckled) Wild rose Quaking aspen (trembling aspen) Balsam poplar Shadbush (Saskatoon or wild pear) Beaked hazel White spruce
Montana (Adams, 1959)	Douglas fir Barberry Ponderosa pine Shadbush (Saskatoon or wild pear)
Michigan (Bookhout, 1965)	Yellow birch (in order of preference) Paper birch White cedar Trembling aspen American elm Sugar maple Jack pine Red pine Eastern hemlock White pine
Manitoba (Criddle, 1938)	Trembling aspen Bur oak White spruce Manitoba maple Beaked hazel Bog birch Wolf willow Wild rose Willows (all species) Hawthorn

Minnesota (Aldous, 1935)	Trembling aspen Willow (several species) Birch (several species)
Newfoundland (four study areas) (Dodds, 1960b)	Paper birch Spruce (black and white) Alder (common or speckled) Shadbush (Saskatoon or wild pear) Gooseberry Rhododendron Blueberry Bog birch Mountain maple Red stemmed dogwood
Quebec (Laurentian area) (Bider, 1961)	Raspberry Beaked hazel Mountain maple Sugar maple Birch (all species) Trembling aspen Beech White spruce Balsam fir Hobblebush (witch hobble)
Ontario (Manitoulin Island) (deVos, 1964)	Sugar maple* Trembling aspen* Paper birch* White pine Red pine White cedar* Beaked hazel* Willow (all species)* Mountain maple Raspberry Ground juniper

* also barked heavily in hard winters

APPENDIX II.
LIST OF WOODY PLANTS BROWSED BY HARE IN NOVA SCOTIA

Balsam fir *Abies balsamea*
Black spruce *Picea mariana*
Red spruce *Picea rubens*
White spruce *Picea glauca*
White pine *Pinus strobus*
Jack pine *Pinus banksiana*
Larch *Larix laricina*
White birch *Betula papyrifera*
Yellow birch *Betula allegheniensis*
Wire birch *Betula populifolia*
Sugar maple *Acer saccharum*
Red maple *Acer rubrum*
Mountain maple *Acer spicatum*
Striped maple *Acer pensylvanicum*
Mountain ash *Pyrus americana*
Red ash *Fraxinus pennsylvanica*
White ash *Fraxinus americana*
Red oak *Quercus rubra*
Trembling aspen *Populus tremuloides*
Beech *Fagus grandifolia*
Alternate-leaf dogwood *Cornus alternifolia*
Black cherry *Prunus serotina*
Apple *Malus pumila*
Pin cherry *Prunus pensylvanica*
Choke cherry *Prunus virginiana*
Willow *Salix spp.*
Speckled alder *Alnus rugosa*
Downy alder *Alnus crispa*
Serviceberry *Amelanchier spp.*
Witch-hazel *Hamamelis virginiana*
Beaked hazel *Corylus cornuta*
False holly *Nemopanthus mucronata*
Canada holly *Ilex verticillata*
Dwarf birch *Betula pumila*
Northern birch *Betula borealis*
Red berried elder *Sambucus pubens*
Blackberry *Rubus spp.*
Blueberry *Vaccinium spp.*
Raspberry *Rubus spp.*
Bearberry *Arctostaphylos Uva-ursi*
Inkberry *Ilex glabra*
Chokeberry *Aronia prunifolia*
Huckleberry *Gaylussacia spp.*
Swamp rose *Rosa nitida*
Wild currant *Ribes spp.*
Sweet-fern *Comptonia peregrina*
Meadowsweet *Spirea latifolia*
Hobblebush *Viburnum alnifolium*
Honeysuckle *Lonicera spp.*
Shrubby cinquefoil *Potentilla fruticosa*
Sweet gale *Myrica gale*
Labrador tea *Ledum groenlandicum*
Leather-leaf *Chamaedaphne calyculata*
Lambkill *Kalmia angustifolia*
Rhodora *Rhododendron canadense*
Witherod *Viburnum cassinoides*
(From Dodds, undated)

APPENDIX III.
SOME SOURCES AND REFERENCES

Nova Scotia
Department of Lands and Forests
P.O. Box 68
Truro, N.S.
B2N 5B8

You can obtain copies of all available wildlife publications sponsored by the Department of Lands and Forests. Single copies will be sent free of charge. Bulk orders can be obtained from the Government of Nova Scotia Bookstore, 1700 Granville St., P.O. Box 637, Halifax, Nova Scotia B3J 2T3.

Atlantic Region

The following may be contacted for available publications from their respective wildlife branches in the Atlantic region.

Newfoundland and Labrador

Coordinator, Information and Education
Wildlife Divison
Department of Culture, Recreation and Youth
Bldg. 810, Pleasantville
P.O. Box 4750
St. John's, Nfld.
A1C 5T7

New Brunswick

Fish and Wildlife Branch
Department of Natural Resources
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

Prince Edward Island

Fish and Wildlife Division
Department of Community and Cultural Affairs
P.O. Box 2000
Charlottetown, P.E.I.
C1A 7N8

There are many sources from which you can obtain information on snowshoe hare and other wildlife. Organization and agency directories are available. Ask your provincial agency for information on these sources and where to write.

General Book References

Animal Rights

Second Nature
The Animal-Rights Controversy
By Alan Herscovici 1985
CBC Enterprises, Toronto and Montreal 254 pp.

Although there are many strident and opinionated non-fiction books and novels supporting animal rights there are few which present an even approach complete with historical information and a highly relevant case-history (Deals with the seal controversy).

Hunting

The Right to Hunt
By James B. Whisker 1981
North River Press 173 pp.

There are also a great many anti-hunting books available including a few written by Canadians. This pro-hunting book examines the religious, anthropological, historical, ethical and legal bases for hunting in the United States. It's relevant here too.

Mammals

The Mammals of Canada
By A.W.F. Banfield 1974 (1977 and 1981)
University of Toronto Press 438 pp.
(Snowshoe hare pp. 80-85)

Wild Mammals of North America
Ed. J.A. Chapman and G.A. Feldhamer 1982
The John Hopkins University Press 1147 pp.
(Snowshoe hare pp. 146-163.)
An excellent reference for the naturalist and hunter alike

Wildlife Management

The Philosophy and Practice of Wildlife Management
By F.F. Gilbert and D.G. Dodds 1986
Robert E. Krieger Publishing Company Inc.
P.O. Box 9542
Melbourne, Florida 32902-9542

Several chapters of interest to naturalists and hunters include wildlife management history, jurisdictions, cultural and social aspects, values, economics and international wildlife problems. This is the *only* text to include Canada and the United States equally throughout.

Wildlife Management on Your Land
By C.L. Cadieux 1985
Stackpole Books, Harrisburg, Pa. 17105

A good popular approach with principles addressed briefly. Most animals considered are not present in Nova Scotia but there are sections on pheasants, grouse and Hungarian partridge, wild turkey, waterfowl, cottontail rabbits (the closest he comes to our snowshoe hare), raccoons, trout, bass and deer.

APPENDIX IV
MAP OF NOVA SCOTIA INDICATING COUNTIES